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for August, 1938

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HANS FISCHER (1881–)

At the Harvard Tercentenary exercises in September, 1936, an honorary doctorate was conferred on Hans Fischer with the citation: A master builder of molecular structure, whose labors tell us why grass is green and blood is red.

Chemists and physiologists have long interested themselves in the relation between the respiratory coloring matters of blood and plant leaves. They are chromoproteins, *i. e.*, a combination of a colorless protein and a pigment; the latter is chiefly responsible for the functioning of the chlorophyll and the hemoglobin.

Both are pyrrole derivatives (Küster, Nencki). The outstanding difference is that the central atom of chlorophyll is magnesium, of hematin, iron.

Removal of the iron from hemin (hematin hydrochloride) leads to the production of the so-called porphyrins (Hoppe-Seyler). These are easily recognized through their characteristic spectra. Similar porphyrins are obtained by removing the magnesium from chlorophyll, clear evidence of the close relationship of the two pigments.

Porphyrins are widely distributed in nature. Patients suffering from porphyrinuria, a metabolic disturbance, excrete large quantities of coproporphyrin and uroporphyrin. A complex copper salt of the latter occurs in the wing feathers of an African bird related to the cuckoo. Pearl-oyster shells contain the calcium salt of conchoporphyrin. Traces of coproporphyrin occur normally in urine, also in bottom yeast, where improper propagation often leads to a considerable increase so that the yeast suffers from a condition comparable to animal porphyrinuria.

The spots on the eggs of the gull, plover, and other birds that nest in the open contain oöporphyrin. This is identical with Kämmerer's porphyrin produced by putrefaction of blood. Prolonged putrefaction of blood leads to deuteroporphyrin, the starting material for the synthesis of hemin.

A thorough study of the chemistry of the pyrroles was a necessary preliminary to the conquest of the main problem. Using the studies of Knorr and Paal as a foundation, Hans Fischer and his collaborators spent many years systematically extending the knowledge of these compounds. All the building blocks of chlorophyll were synthesized, numerous methods of preparing porphyrins were discovered and developed so that examples are known in the laboratory that have not been found in nature or obtained from hemin. The way to the synthesis of hemin was paved by about twenty years of this type of research. The greatest obstacle was the existence of isomers, not less than fifteen are predicted by theory. The synthesis of hemin ($C_{34}H_{32}O_4N_4FeCl$) has now been accomplished.

Chlorophyll presents a task of different proportions though success may be reached in the not-too-distant future. Thus far it has been established that the side chains have the same arrangement as in hemin; also the porphyrins resulting from the deep-seated degradation of chlorophyll are synthetically accessible.

Hans Fischer was born July 27, 1881, at Hoechst am Main. He studied chemistry and medicine at Lausanne, Marburg and Munich: Ph.D. (1904), M.D. (1908). A thorough training in responsible assistantships in the clinics at Munich and in Emil Fischer's laboratory at Berlin qualified him to teach physiology, internal medicine, and chemistry. He succeeded Windaus at Innsbruck (1916) in the chair of applied medical chemistry, in 1918 he moved to Vienna as successor to Mauthner, and in 1921 he took his present position when he succeeded Wieland in Munich as head of the organic chemical institute of the Technical High School.

From his laboratory have come about three hundred papers, chiefly on bile pigments, chlorophyll, pyrrole derivatives, blood pigment, and so forth. In 1930 he was awarded the Nobel Prize.

(*Contributed by Ralph E. Oesper, University of Cincinnati*)

EDITOR'S OUTLOOK

THE SOCIAL RESPONSIBILITY OF THE SCIENTIST. The subject is anything but novel. Indeed, it remains attractive only because it has been productive of so much utter nonsense that the impulse to let a draft of common sense blow through the smoke screen becomes overpowering at times.

One of the pet themes of the more articulate ignoranti has been the charge that science has unloosed a veritable Pandora's box of destructive forces to prey upon a defenseless world. The implication is that a greater sense of social responsibility on the part of scientists would have nipped in the bud many of the ills that now beset us. The absurdity of the entire thesis is most briefly demonstrated by reducing it to its two fundamental postulates. These are (1) that it is humanly possible to perceive prior to discovery all the potential applications of a given bit of scientific knowledge, or of a given invention, and (2) that all discoveries or inventions that seem capable of misapplication should be, for that reason, suppressed at or before birth.

Doubtless the cave man should have recognized fire as the potential tool of the arsonist, and should have smothered it. Doubtless the domesticator of the horse should have seen in that apparently innocent animal the means of transportation of all highwaymen and raiders from the dawn of history to the early twentieth century, and should have left the beast alone or exterminated his kind. Perhaps bronze and, later, steel were early recognized as materials suitable for the fabrication of lethal weapons; doubtless they should have been suppressed.

But of course no critic of science, however intellectually foolhardy he may be, attempts to defend these logical outposts of his territory. He falls back upon prepared positions that he conceives to be more readily defensible. In defiance of the ancient but generally sound adjuration never to give a sucker a break, let us meet him in his supposedly impregnable stronghold, surrounded by his favorite exhibits of engines of destruction. Let him call all these, if he will, the direct products of science.

Let him select what exhibit he fancies most; can he sustain the charge that it is *prima facie* evidence of the social irresponsibility of some scientist or group of scientists? If my tribe has been the victim of repeated attacks perpetrated by rock- and club-bearing raiders, am I totally lacking in social responsibility if I contrive the bow and arrow for defense against them? If the raiders learn the trick eventually and return with bows and arrows, have I been lacking in social responsibility if meantime I have been preparing to outrange and outfire them with blunderbusses? When they have mastered the blunderbuss, is it social irresponsibility on someone's part that enables their intended victims to repel them with rifles? Only the screwball who insists that umbrellas invite rain could so argue.

The simple truth is that weapons cannot be classified either as defensive or aggressive. Purely passive defense always fails. All successful resistance to aggression must involve some measure of counterattack.

The long and short of the matter is that no scientist can either foresee or control all the applications of his discoveries. Even when he can clearly foresee deplorable applications, he is often justified by circumstances in proceeding, notwithstanding. His social responsibilities are precisely those of any good citizen—neither more nor less.

JEAN SERVAIS STAS*

JEAN TIMMERMANS

University of Brussels, Brussels, Belgium

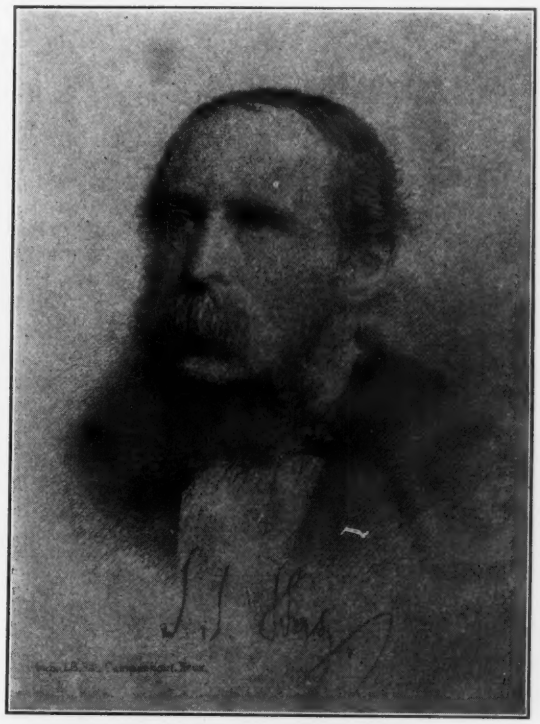
JEAN SERVAIS STAS was born at Louvain, August 21, 1813, the son of the proprietor of a small locksmithery. The precocity of his intelligence and his rather delicate health predisposed the boy to an intellectual career. After a classical course at the college in his native city, Stas took up the study of medicine and obtained his degree, with distinction, at the University of Louvain in 1835. He had chosen this curriculum because at that time, in Belgium, the faculty of medicine alone was sufficiently well organized to give a worth-while training in experimental science.

An early disciple of Lavoisier, Van Mons, who had done much to spread the principles of modern chemistry in Belgium, inspired Stas' interest in chemistry. He engaged Stas as his assistant and taught him the niceties of chemical manipulation. His duties did not sufficiently occupy Stas, and he fitted up a small private laboratory in the dusky attic of his father's house. Most of his equipment was made with his own hands, notably his balance. This was entirely of metal, except the pointer: a thread of glass drawn out in the flame and attached by a speck of sealing wax. The materials cost only five francs (approximately one dollar), but this balance was sensitive to one milligram.

Van Mons was also much interested in the improvement of fruit trees; some of his varieties of apples were introduced into the United States with excellent success. He had a large experimental nursery just outside Louvain, but this was almost completely destroyed by a French army that camped there in 1830, on its way to aid the Belgians at the siege of Antwerp. The examination of some new roots of these fruit trees led Stas to his first discovery, phloridzin. This glucoside has the remarkable property of producing a temporary glycosuria; the physiological mechanism of this artificial diabetes has not been established as yet.

Encouraged by Van Mons, in 1837 Stas went to Paris to complete his scientific education. Thénard, Gay-Lussac, Laplace, Arago, Biot, and others made up the galaxy of scientific stars active there, but it was Dumas particularly who attracted the young Belgian. In Dumas' laboratory he made the intimate acquaintance of several young men who, like him, were destined for a brilliant career, notably Sainte Claire Deville and Cahours. When Stas' funds were exhausted, Dumas, impressed by the exceptional promise of his collaborator, kept him in Paris at his own expense. He made him an associate in his researches, more particularly setting him the task of redetermining the atomic weight of carbon.

The then-accepted value was 12.053, a figure obviously too high, because when used with materials rich in carbon, naphthalene for instance, the calculation gave a weight of material greater than that of the sample taken for the combustion analysis. Dumas and Stas, in a study that is still a model, burned carbon (graphite, diamond) in pure oxygen, and from the weights of carbon and of carbon dioxide (absorbed in alkali) found the atomic weight of carbon to be 12.00.



JEAN SERVAIS STAS (1813–1891)

In 1841, Stas returned to Brussels as professor of chemistry at the École Militaire. By dint of his persistence he convinced the authorities of the absolute necessity of providing him with the means of illustrating his lectures with experimental demonstrations.

* Translated by Ralph E. Oesper, University of Cincinnati.

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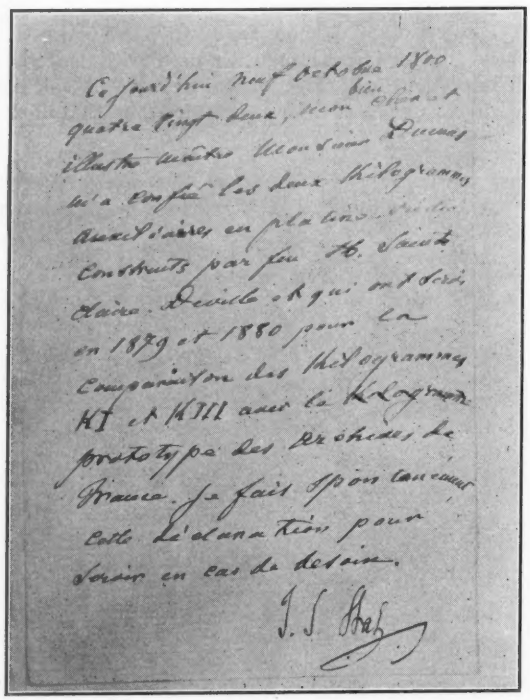
He taught in this school until 1865 when throat trouble that affected his speech forced him to resign his chair. During these twenty-five years he carried out his famous determinations of atomic weights.

These investigations were made at his house in a suburb of Brussels. His patrimony and a considerable part of his salary went to meet the expense of this private laboratory. In 1860 he wrote to his father, "To achieve my works, I have made sacrifices that have brought me not far from poverty." Liebig learned of this situation and generously offered to obtain for Stas a pension from Ludwig, King of Bavaria, who was proud to act as an enlightened patron of the sciences. Stas patriotically declined with thanks and asked for a grant from the Belgian Ministry of Public Education. Finally, he was given six thousand francs, payable in three years; this was not even one-tenth of the amount that he had spent. Under such material circumstances he carried out the researches which made him the greatest chemist contemporary Belgium has produced.



RECEIPT FOR TWO PLATINUM INDIUM AUXILIARY STANDARD KILOGRAMS, SENT TO STAS BY DUMAS

When Dumas and Stas proved the atomic weight of carbon to be a simple sub-multiple of that of oxygen, they provided an experimental argument in favor of Prout's hypothesis. In 1815, this English physician had advanced the idea that all atomic weights are whole numbers if the atomic weight of hydrogen is taken as unity. Stas set himself the task of discovering, by measurements of the highest possible precision, if the atomic weights of other elements likewise conformed to this rule. In 1860 he published the fruit of ten years of toil.[1]

The results demonstrated indubitably the untenability of the Proutian hypothesis, in which Stas at the beginning of his atomic weight work had had absolute confidence. In a letter to Napoleon III he recalled these findings, "I have been vanquished by experiment."

Stas' determinations aroused general admiration, but Marignac of Geneva tried to rescue Prout's hypothesis by throwing doubt on the constancy of the law of combining proportions. For example, he asked if the relation of the atomic weight of chlorine to that of silver is exactly the same in silver chloride and silver chlorate. To refute this objection Stas resumed his determinations. These subsequent results were published in 1865.[2]

These data presented a rigorous demonstration of the invariability of the relative atomic weights of elements in their different compounds, and Louis Henri of Louvain has proposed that this fundamental principle of the constancy of atomic weights be known as Stas' Law.

When Stas retired from his professorship at the military school he was appointed Commissioner of the Mint. The coinage of Belgian money was farmed out as a monopoly to a contractor, who struck the coins at the mint, whose equipment was placed at his disposal. It was the function of the Commissioner of the Mint to oversee this fabrication; no coin could be put into circulation without his authorization. Stas conducted this office with scrupulous honesty and unwavering firmness which yielded to no authority, not even the Minister. Naturally, then, in 1872, when it was attempted to reduce his rôle to that of a mere employe, he resigned this well-paying position and chose rather to live on his small pension from the École Militaire.

At the Mint, Stas invented a method of purifying gold that is still in use. He never published this work; it was found among his papers and was not put into print until 1937, when the Belgian Chemical Society celebrated its fiftieth anniversary.[3] In this laboratory he improved the Gay-Lussac method for the determination of silver, recommending the use of bromide in place of chloride. In this connection he made an intensive study of silver chloride and bromide; his results aided in preparing gelatin bromide rapid photographic plates.

After his retirement, Stas continued his researches on the elements; the results were published posthumously. Dumas, in 1878, had found that pure silver

[1] STAS, "Recherches sur les rapports réciproques des poids atomiques," *Bull. Acad. Royal. Belg.*, **10**, 208 (1860).

[2] STAS, "Nouvelles recherches sur les lois des proportions chimiques, sur les poids atomiques et leurs rapports mutuels," *ibid.*, **35**, 3 (1865).

[3] *Bull. soc. chim. Belg.*, **46**, 367 (1937).

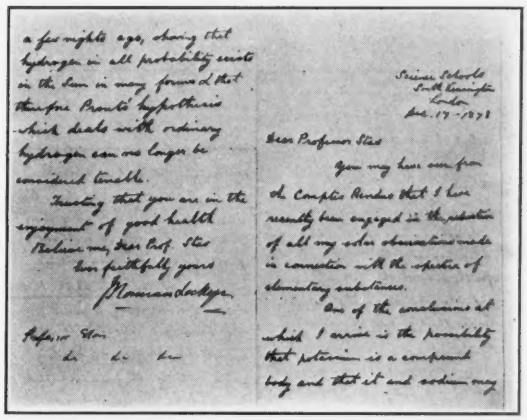
fused and solidified in contact with air occludes a small quantity of oxygen, which may lower the titer of the metal by 1–2 parts in 10,000. This observation endangered the whole of Stas' work because silver was the intermediary in his determinations of the atomic weights of quite a few elements. Stas was sixty-five years old, but this man whose work has been stated "to represent the maximum of human patience applied to quantitative analysis" retraced his steps and was able to finish the re-examination before his death. He showed that, under the conditions obtaining in his measurements, the error in the atomic weight of silver was less than $^1/_{30,000}$ and this was without effect on his other results. Even Richards was not able to correct Stas' values until he found that fusing silver in hydrogen, a procedure used by Stas, leads to occlusion of this gas.

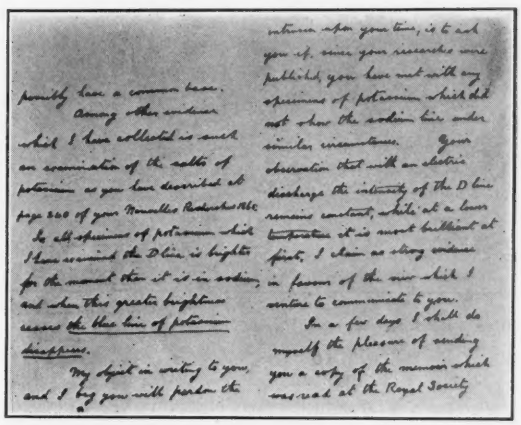
The excellence of Stas' determinations is shown in the following table:*

	Stas Hydrogen = 1	*Stas Oxygen = 16*	*International, 1937 Oxygen = 16*
Oxygen	15.960	16.0	16.000
Silver	107.660	107.930	107.880
Nitrogen	14.019	14.055	14.008
Sulfur	31.990	32.070	32.06
Chlorine	35.368	35.457	35.457
Bromine	79.750	79.952	79.916
Iodine	126.533	126.850	126.92
Potassium	39.044	39.1425	39.096
Sodium	22.988	23.0455	22.997
Lithium	7.004	7.022	6.940
Lead	206.396	206.913	207.21
Carbon	11.969	11.99	12.01

Another very important question engaged his attention in the course of this study, the stability of the elements. Lockyer believed that he had observed the characteristic lines of other elements in the spectra of the very hot luminous flames of certain metals. For instance, above a certain temperature the yellow line of sodium could be found with all the elements. From these observations the English astro-physicist deduced the possibility of the thermal decomposition of the elements, a seductive hypothesis quite in harmony with the idea which has always haunted the minds of chemists: the unity of matter. Stas, over a period of ten years, prepared specimens of potassium and silver salts so pure that they showed not a trace of the sodium line, even at the melting point of iridium or in the electric arc, provided the surrounding atmosphere contained no traces of sodium. He summed up his conclusions in a notable lecture delivered to the Academy in 1890.[4]

Stas represented Belgium on the International Committee of Weights and Measures; as an expert on noble metals he was asked to collaborate with Sainte Claire Deville in the preparation of the alloys used for the construction of the standard meter. His services were always available in matters concerning the public welfare: the preparation of the geological map of Belgium, methods of preventing the counterfeiting of bank notes, the manufacture of gun steels, the Commission of Hygiene, the Committee of the Royal Library, are cases in point.





LOCKYER TO STAS, SUGGESTING THAT POTASSIUM IS A COMPOUND

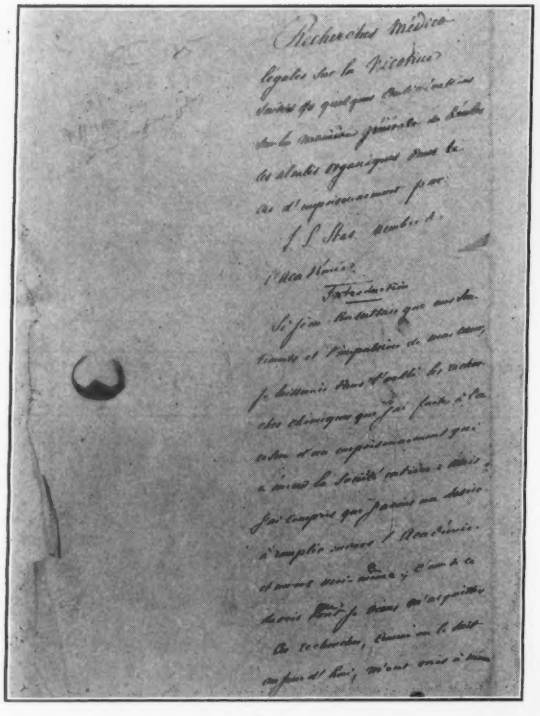
He was a recognized authority on medico-legal matters. One murder trial in which he took a leading part has had a lasting influence in toxicology. Nicotine poisoning was suspected as the cause of death, but at that time no reaction characteristic of this alkaloid was known. Stas, as government expert, on this occasion devised the still-used "Stas" method of detecting vegetable alkaloids.

Though he was brought up a Catholic, he professed no positive religion and always exhibited much tolerance, which in his case took the form of great independ-

* MALLET, J., Stas Memorial Lecture: "Jean Servais Stas and the measurement of the relative masses of the atoms of the chemical elements," *J. Chem. Soc.*, **63**, 1 (1893).
See also *Proc. khem. Soc.*, **1892**, 203, for interesting discussions of this instructive paper.

[4] STAS, "Discours de la nature de la lumiere solaire," *Mem. Acad. Roy. Belg.*, **49** (1891).

ence in the accomplishment of what he conceived to be his duty. There was much of the Stoics in him. The independence of his character, his moderation, his lack of self-interest, taken together with the extent and depth of his knowledge, gained for him a position of influence in Belgium and other countries. Through him, the Belgian Academy elected to its membership his colleague at the Catholic University of Louvain,



INTRODUCTION TO THE PAPER ON NICOTINE POISONING

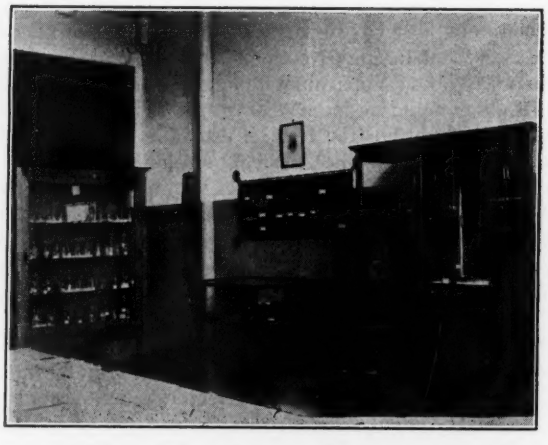
Louis Henri, whose first researches on the structure of nitriles and the equivalence of the four valences of carbon had been guided by Stas; it was on his advice that the University of Ghent called Kekulé, who attracted students from all Europe; again it was Stas who secured the nomination as director of the observatory at Uccle, of Houzeau, who was recalled from Jamaica where he had gone into voluntary exile after taking an active part, even in Texas, in the anti-slavery struggle. His advice and example were decisive in the choice of his profession by Walter Spring, who eventually became Professor of Chemistry at Liége.

Stas never married, but adopted (unofficially) the small sons of his concierge. To the end of his life, he retained his post as President of the Central Jury of Pharmacy so that he could use the fees to accumulate a small sum to be used for the education of these young friends. This confidence was not misplaced; one of them is now a high officer in the Belgian army.

Honors came to him from the whole world of science. Four times he headed the Science Section of the Belgian

STAS MEMORIAL, GARDEN OF THE ACADEMIE DES SCIENCES, BRUSSELS

Academy and in 1890 he was chosen to fill the highest post, the Presidency of the Academy. In this capacity, on January 1, 1891, he carried to Leopold II its New Year greetings and read to the king a discourse that created quite a sensation. Protesting against the injection of politics into the recruiting of the faculties of



STAS MUSEUM, UNIVERSITY OF BRUSSELS

the state universities, he said, "Instead of bestowing the university chairs on the most capable men as proper rewards of merit, with the sole purpose of raising the level of the courses and of increasing the intellectual heritage of mankind, only too often does the spirit of partisanship show itself by the arbitrary disposal of

these posts to the detriment of the scientific spirit. An incompetent professor can cause the stagnation for a quarter of a century of the instruction in the department entrusted to him, even if he does not accomplish its decline." (This eloquent appeal, unfortunately, fits the conditions in many countries even today.)

Stas died, December 13, 1891, and was buried in Louvain. The resentment incited by his statement before the king was still very much alive. The Academy unanimously requested the government to purchase, for a very modest sum, the souvenirs left by this great man and noble citizen. The petition was denied. Then, on the suggestion of Professor Heger of the University of Brussels, the collection was bought by the great industrialist, Ernest Solvay, and deposited at the University. In the *Salle Jean Stas* in the Chemical Department are exhibited Stas' library, rich in alchemical items; some of his famous balances, constructed under his own direction and weighing five kilograms almost to the milligram; a collection of chemical products used in his researches and which escaped the disastrous fire that destroyed one of his laboratories. The personal mementoes include his passport for Paris (1837), his medals, including the Davy Medal and several struck in his honor, portraits, and finally his laboratory journals, his manuscripts and his immense correspondence.*

This mass of documentary material has recently been classified and cataloged.[5] It offers an extremely valuable fund of source material to students of the internal history of Belgium, and particularly to those interested in the development of chemical thought in the second half of the nineteenth century. The hundreds of letters include important and interesting items from Dumas, Bunsen, Baeyer, Kekulé, Lockyer, Sainte Claire Deville, Wurtz, Van Mons, Solvay, Houzeau, and others.

STAS MUSEUM, UNIVERSITY OF BRUSSELS

The collected works of Stas were published, thanks to funds publicly subscribed, by the Royal Academy of Belgium.[6] W. Spring, who edited this tribute to his great friend and master, included an authentic biography, on which the present writer has drawn rather freely.

* *Translator's note.*—The chemical world owes much to the author of this sketch, Professor Timmermans, who rescued this literary heritage from probable destruction.

[5] PELSENEER, J., *Bull. Soc. Chim. Belg.*, **46**, 377 (1937).

[6] STAS, JEAN SERVAIS, "Oeuvres completes," 3 vols., Brussels, 1894.

PRODUCTION *of* CHEMICALS *by* MINUTE ORGANISMS

A. W. HIXSON AND RAYMOND R. ROGERS

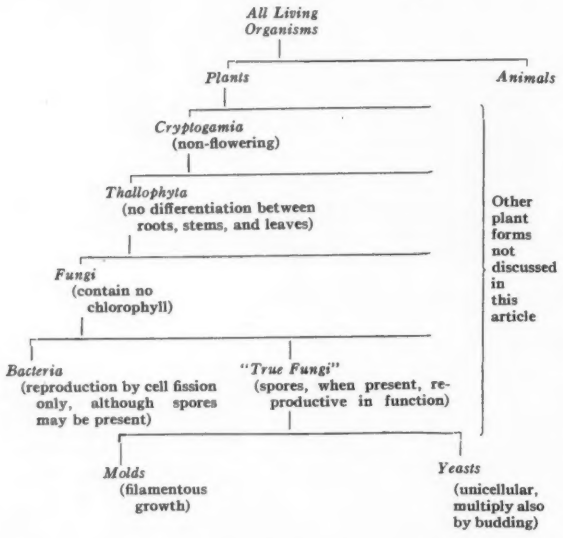
Columbia University, New York City

AN UNFAILING supply of food has always been a fundamental requirement for man's existence. Down through the centuries many other chemical materials also have proved to be useful to man, though perhaps not essential. The great majority of these important materials have been obtained from the plant and animal life in field, forest, and water. Although man's dependence upon other forms of life has always been recognized, there have been hundreds if not thousands of different plant and animal species in existence of which our forefathers of several centuries ago had not the slightest knowledge. It was not until after the ad-

vent of the microscope that man learned of these minute organisms and began to study them. Now we know that they are as important to our well-being as the larger plants and animals which may be seen with the naked eye.

These minute organisms produce food and other chemical materials of great value to man. They also break up dead tissue, of both plant and animal origin, into simple constituents which are returned to the soil or to the atmosphere where they can be utilized as food by living organisms. On the other hand, some of these

TABLE 1


All Living Organisms
Plants
Animals
Cryptogamia (non-flowering)
Thallophyta (no differentiation between roots, stems, and leaves)
Fungi (contain no chlorophyll)
Other plant forms not discussed in this article
Bacteria (reproduction by cell fission only, although spores may be present)
"True Fungi" (spores, when present, reproductive in function)
Molds (filamentous growth)
Yeasts (unicellular, multiply also by budding)

organisms are capable of producing undesirable chemical changes as in the spoilage of food. Others produce disease in man as well as in plants and animals. This article will deal largely with the production of useful chemicals by bacteria, yeasts, and molds, all of which are considered to be minute plants.

Pasteur (1822–1895) will always be remembered as the outstanding pioneer in the study of these minute organisms. Practically all of our present scientific knowledge in this field has been gained since Pasteur began his researches. The field is an enormous one, and as yet only its edge has been touched. Naturally, much more time and money have been devoted to the study of pathogenic (disease-producing) organisms than to the study of the non-pathogenic species. However, for obvious reasons, the latter are of greater importance in the large-scale production of chemicals.

A thorough biological classification would be out of place in this article. In fact, biologists are still in disagreement regarding many of the details of classification. However, a brief summary, such as that given in Table 1, showing the general relationship of the yeasts, molds, and bacteria to one another and to the larger plants, should prove to be helpful. Although bacteria are generally classed as plants, it must be admitted that they have some characteristics in common with the animals. For instance, their cell walls are not composed of cellulose as in the case of plants in general. Moreover, some of the bacteria possess motility which is usually considered to be a characteristic of animals.

TABLE 2

	Typical Diameter (millimeters)
Viruses (which cause smallpox, infantile paralysis, etc.)	0.00006
Pleuropneumonia Organism (smallest to be seen in microscope)	0.00015
Streptococcus	0.001
Azotobacter	0.005
Yeast Cells	0.01
Filamentous Fungi	0.03

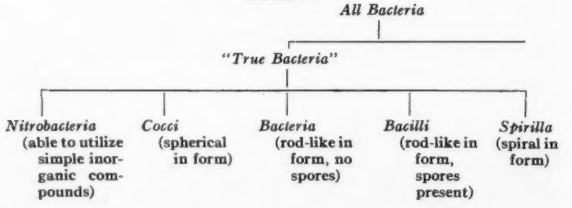
Although, in general, these organisms are extremely small, there is a wide variation in size from one type to another as shown in Table 2. It should be added that some of the fungi, such as the morel, are much greater than 0.03 mm., which is the value given in Table 2 for filamentous fungi.

BACTERIA

Enough is not yet known regarding bacteria to establish for them a consistent and uniform classification and nomenclature. At present their names are a matter of convenience and current and local usage. However, attempts to improve this situation are continually being made. Although complicated names such as "Granulobacillus saccharobutyricus mobilis nonliquefaciens" will sometimes be found in the literature the modern tendency, fortunately, seems to be in the direction of simplification.

Perhaps the best present-day classification of the bacteria is given in Table 3.

TABLE 3


All Bacteria
"True Bacteria"
Nitrobacteria (able to utilize simple inorganic compounds)
Cocci (spherical in form)
Bacteria (rod-like in form, no spores)
Bacilli (rod-like in form, spores present)
Spirilla (spiral in form)

Bacteria, like all other forms of life, require energy in order to grow and reproduce. None of the bacteria possess chlorophyll, and only a few of them possess pigments somewhat similar to chlorophyll. Accordingly, the great majority of them must obtain their energy from the chemical materials with which they are in contact. These materials may consist of the tissue of living or dead plants and animals or they may consist of inorganic materials found in nature. On the other hand, they may be mixtures of chemical substances which have been artificially prepared.

Some materials are absorbed by the organism from the surrounding medium. These undergo chemical change inside the organism. Other materials, situated near the organism, also frequently undergo chemical change. Many of these chemical effects, both inside

and outside of the organism, occur due to the presence of organic catalysts (enzymes). It is interesting to note that, in general, these organic catalysts are much more effective than inorganic catalysts. For example, the enzyme catalase, prepared from red corpuscles, is about twenty times as effective in decomposing hydrogen peroxide as an equivalent amount of colloidal platinum.

Energy is liberated by the chemical processes of the organism all taken together, even though some of the individual reactions may absorb energy. Part or all of the energy liberated is used by the organism to enable it to continue its life processes.

The nature of the many products of the reactions which take place in or near the organism depends upon the type of organism and upon the chemical and physical environment with which it is in contact. Some organisms seem to be much more active, chemically, than others. In Table 4 four common types of bacteria are compared in regard to the acid and gas produced when they are in contact with certain chemicals (dextrose, lactose, raffinose, and mannitol).

TABLE 4

	Dextrose	*Lactose*	*Raffinose*	*Mannitol*
Aërobacter aërogenes	acid, gas	acid, gas	acid, gas	acid, gas
Alcaligenes fecalis	—	—	—	—
Proteus vulgaris	acid, gas	—	—	—
Eberthella typhi	acid	—	—	acid

Aërobacter aërogenes, Alcaligenes fecalis, and Proteus vulgaris are frequently found in water. The latter is important in the tanning of leather and the curing of tobacco. Eberthella typhi is the organism responsible for typhoid fever. It will be observed that, in some cases, both acid and gas are produced, in others only acid, and in still others neither one.

Most bacteria can thrive upon a comparatively simple mixture of materials. A broth containing beef extract, peptone, and sodium chloride has proved to be a satisfactory liquid medium. To produce a solid medium, agar may be added to this broth. A number of other mixtures, frequently more complicated, are necessary in order to obtain best results in some cases. Although a nutrient medium which is neutral or slightly alkaline is best for most bacteria, there are some exceptions. For instance, the organism which is responsible for cholera prefers a pH of 8 to 9, while the most important organism in acidophilus milk (Lactobacillus acidophilus) prefers a pH of about 5. As shown in Table 4, the materials produced by an organism will depend upon the constituents of the medium.

The activity of bacteria may give rise to either an acid, neutral, or alkaline reaction. In general, acidity is caused by the fermentation of a sugar, alcohol, or similar material in the nutrient medium. The liquefaction of gelatin by bacteria is accompanied by an increase in acidity. As a rule, however, the disintegration of protein substances is responsible for an increase in alkalinity.

The rate of reproduction of bacteria gradually decreases as the concentration of the different reaction products increases. In other words, when the reaction products reach too high a concentration they act as a poison upon the bacteria. For instance, too great a concentration of hydrogen or hydroxyl ion will produce an effect of this kind.

The presence or absence of oxygen is frequently of great importance. Some organisms can thrive only in the presence of oxygen (aërobes). Others can thrive only in the absence of oxygen (anaërobes). On the other hand, some apparently can live normally in either the presence or absence of oxygen.

In the bacterial decomposition of nitrogenous materials the substances which may be formed include ammonia, carbon dioxide, hydrogen, marsh gas, hydrogen sulfide, nitrogen, amides, peptones, various aromatic bodies, mercaptan, and skatol. Those produced under anaërobic conditions differ materially from those formed in the presence of oxygen. Anaërobic decompositions, for example, are much more likely to be accompanied by the evolution of offensive gases.

Most bacteria are much more sensitive to high temperatures than to low ones. A number of types have been exposed to the temperature of liquid air (about −190°C.) without destroying their vitality. On the other hand, most bacteria which do not produce spores are killed by a ten-minute exposure at 58°C. in the presence of moisture. However, some bacteria have been found in the water of hot springs at 89°C. Bacteria which do not produce spores are killed by a pressure of 6000 atmospheres exerted for fourteen hours. Spores are more resistant to high temperatures and pressures than are the vegetative bacterial forms.

Although bacteria are capable of producing a wide variety of chemical changes there is space in this article to mention only a few of the processes which are of commercial importance.

VINEGAR MANUFACTURE

Vinegar can be made from a wide variety of products, the most common being cider, grape juice, and malt extracts of grains. From the point of view of the vinegar manufacturer the important substance in these materials is sugar.

The process really takes place in two distinct steps: (1) the production of alcohol from the sugar by means of a yeast, and (2) the production of acetic acid from the alcohol by means of bacteria. In some cases the two processes are allowed to take place one after the other in the same container. In others, different containers are used. The action of yeasts will be discussed later.

There are a number of bacteria which are capable of acting upon the alcoholic solution, derived from the cider or other raw material, to produce acetic acid. In practice, the work is actually done by several different organisms. This is one case where the use of pure cultures is neither essential nor economical.

Assuming that the alcoholic solution contains sufficient food materials for the bacteria, the success of the alcohol-to-acetic acid process depends largely upon the

temperature and the supply of oxygen. The temperature used by American manufacturers is usually about 32°C. Since the process is one of oxidation the greater the surface exposed to the air the better. One process illustrates this point particularly well. A large wooden vat is filled with beechwood shavings which offer a great surface exposure. A batch of old vinegar is allowed to trickle over the shavings in order to inoculate them with the proper bacteria. Then the alcoholic solution is allowed to trickle slowly over the shavings. By the time it has reached the bottom most of the alcohol has been converted to acetic acid.

LACTIC ACID MANUFACTURE

Due to this process a considerable amount of the surplus whey produced in the dairy industry need no longer be a valueless by-product. Whey contains about five per cent. of lactose which, by this process, is changed to lactic acid or lactates. Although two organisms are used in the process, Lactobacillus bulgaricus (a non-spore-bearing, rod-like bacterium) is the most important. It can thrive either in the presence or absence of oxygen and in many other respects is quite similar to the organism of acidophilus milk. In order to keep the acidity of the liquid within the range for best bacterial growth, lime is added from time to time which results in the formation of calcium lactate. If lactic acid is required, this lactate is treated with sulfuric acid.

ORDINARY SOURING OF MILK

The souring of ordinary milk is another case of the fermentation of lactose to produce lactic acid. It is probably due to the activities of two organisms: Aërobacter aërogenes (a non-spore-forming, rod-like bacterium) and Streptococcus lacticus (a coccus), the former being largely responsible for the initial stages of the process and the latter for the final stages. In these days, before use, milk is frequently heated to 60–65°C. for some time (pasteurization). This operation kills all of the pathogenic and most of the other bacteria ordinarily present and the subsequent souring of the pasteurized product is due almost entirely to Streptococcus lacticus which is one of the survivors.

BUTANOL–ACETONE–ETHANOL MANUFACTURE

This industry was a product of the Great War. At that time large quantities of acetone were urgently needed by the British as a solvent for nitrocellulose in the production of smokeless powder, and by the Americans for aëroplane dope. The ordinary processes could not meet the demand. Eventually, a fermentation process was developed in which acetone was produced together with butanol and ethanol in the ratio of 3:6:1. There was no demand for large quantities of butanol so, when it was separated from the other products, it was stored in large tanks. Some years later the picture changed completely. Butanol became of utmost importance in the new lacquer industry, and the acetone became a secondary product.

The raw material in this process is a starch solution obtained from low-grade corn which is unfit for feeding purposes. This is acted upon by the organism Clostridium acetobutylicum (an anaërobic, spore-forming, rod-like bacillus) and a combination of butanol, ethanol, acetone, and water is distilled from the resulting material. The solid by-products are sold as stock food.

ACTION OF BACTERIA UPON NITROGEN AND ITS COMPOUNDS

In view of the fact that nitrogen is an important constituent of all forms of life, the action of bacteria in breaking down and synthesizing nitrogen compounds is of great importance. The supply of nitrogen in the atmosphere is not directly available to plants. However, there are bacteria that are capable of starting with elementary nitrogen and building up nitrogen compounds which can be used as food by plants (nitrogen-fixation). There are other bacteria which are capable of disintegrating the dead tissues of plants and animals to form ammonia (among other substances). Ammonia cannot be used as food by certain forms of life, but there are bacteria which can oxidize ammonia to form compounds which can be used as food (nitrification). On the other hand, there are organisms which are capable of reducing nitrates to nitrites, ammonia, oxides of nitrogen, or even to elementary nitrogen (denitrification). The importance to agriculture of this destruction of nitrogenous food materials is not very great.

The most important organisms which are responsible for ordinary nitrogen-fixation are Clostridium pastorianum (an anaërobic, spore-bearing, rod-like bacillus) and several species of Azotobacter (a round or oval non-spore-forming aërobe). The presence of certain carbohydrates favors the process of fixation.

Then nitrogen is fixed by another type of organism, Rhizobium radicicola (a non-spore-forming, rod-like aërobe) which produces nodules on the roots of leguminous plants such as clover, peas, and beans.

Nitrification is produced in two distinct steps, each step being due to the activity of a different organism. The ammonia-to-nitrite step is due to the organism Nitrosomonas which is capable of assimilating all of its carbon in the form of carbon dioxide and building it into the necessary complex organic tissues by means of the energy obtained through the oxidation of ammonia. The organism cannot utilize the carbon of more complex organic compounds, nitrogenous or otherwise. Not even the amines, so closely related to ammonia, can be of use to the organism. Less is known about the organism which is responsible for the nitrite-to-nitrate step.

YEASTS

Yeasts are found free in nature wherever there is sugar present: in the foodstuffs of man, in the nectar of flowers, the exuded sap of trees, and, above all, on the surfaces of fruits. They are also found in soil and on the leaves of plants.

Yeasts usually grow more slowly than bacteria, but they can thrive in foods preserved from bacterial action by high acidity or high osmotic pressure. Nevertheless, much that has already been said regarding bacteria applies also, to a certain degree, in the case of yeasts. Many of the latter thrive under semianaërobic conditions and, for the most part, they are not active in the decomposition of proteins. Yeasts, like bacteria, depend to a great extent upon enzyme action to produce necessary chemical changes. They cannot ferment polysaccharides. Starch, for instance, must first be converted into maltose by means of an enzyme from some other source. However, most yeasts can ferment the disaccharides sucrose and maltose and a few can ferment lactose also.

The yeasts are of industrial importance chiefly in connection with the alcoholic fermentation which they produce, although the amount of yeast used as food is increasing annually. The alcohol produced is not, in most cases, used as a food by the organisms. Perhaps the most important benefit derived from the alcohol by the yeast is one of protection. Yeasts can tolerate more alcohol than most other organisms. Hence, by producing alcohol in the sugar solutions, they are able to get rid of molds and bacteria which are competing organisms.

The true yeasts form spores. However, there are closely related organisms which do not form spores. These are, at present, of no commercial value and are sometimes known as "wild yeasts" because they have been the cause of frequent failures or undesirable fermentations in industrial processes. All of the yeasts of industrial importance at the present time belong to the genus Saccharomyces.

Some yeasts remain at the top of the liquid in which they are produced, and others remain in the depths during fermentation. "Top" yeasts tend to remain attached to each other in clusters and to produce carbon dioxide vigorously so that they are carried to the top of the fermenting liquid in a froth. "Bottom" yeasts grow and ferment somewhat below the surface.

Saccharomyces ellipsoideus, which forms elliptical cells, is found naturally on grapes and in the soil of vineyards. It will generally outgrow other yeasts or molds.

Saccharomyces pastorianus, which forms large, sausage-shaped cells, is a frequent contaminant in brewing and may usually be found in commercial yeast cakes.

Some yeasts can bring about the fermentation of the lactose in milk to produce alcohol. The "bottom" yeast, Saccharomyces fragilis, with cells oval to elliptical, is the best known of these.

The manufacturer of yeast for bread-making or for nutritional use is largely concerned with "top" strains of Saccharomyces cerevisiae, an organism which forms rather large cells either round or plumply oval in form.

An approximate analysis of yeast is given in Table 5. In its manufacture the assimilable sugars of molasses or of mashed cereal grains are used to supply the carbon content.

If necessary, yeast can also use amino acids, lactic acid, and (under certain conditions) ethyl alcohol. It is unable to assimilate elementary nitrogen, nitrites, or nitrates but can utilize ammonia, urea, and peptones. In present commercial yeast production nitrogen probably is supplied entirely by ammonia. As this ammonia is consumed by the yeast the liquid tends to become more acid. To prevent this, ammonia has to be added during the process. Approximately ninety per cent. of the inorganic constituents of yeast consists of phosphorus and potassium. The raw materials used in the process usually furnish sufficient potassium but may be deficient in phosphorus. This is usually added as ammonium or calcium phosphate.

During the past twenty years a great deal of interest has been shown in yeast as a source of Vitamins B and G. Yeasts with a high fermentation rate do not necessarily possess a high Vitamin B or Vitamin G content. The vitamin content can be effectively preserved when yeast is properly dried and the preparation of this dry yeast has become of considerable importance.

TABLE 5

Carbon	45 per cent.
Nitrogen	9 per cent.
Oxygen	32 per cent.
Hydrogen	6 per cent.
Inorganic material	8 per cent.

It has also been found that Vitamin D is produced in yeast when it is irradiated with ultra-violet light. This treatment in no way affects the baking quality or Vitamin B and G content of the yeast, or its manner of reproduction. When irradiated yeast is fed to cows the milk of the latter possesses a considerable amount of Vitamin D. Milk produced in this way is not modified in color, taste, or any other property.

MOLDS

The molds grow more slowly than bacteria. For that reason, we ordinarily do not find them growing in conditions where they are forced to compete with the latter. But where conditions are unfavorable to bacteria one or more species of mold usually will be able to develop. For instance, molds will grow on starchy foods or foods containing a high concentration of sugar or a high acidity. These conditions are unfavorable to bacterial growth. Molds will grow, at times, upon material which does not seem capable of supplying a great deal of nourishment, provided that the material is sufficiently damp. They can thrive on much smaller amounts of water than are required by bacteria.

Although a few species of mold may grow, to some extent, under a reduced oxygen tension, there are probably no strictly anaërobic molds, and the great majority are definitely aërobes.

Molds are much more numerous than bacteria in acid soils, and many are present even in soils having a neutral reaction. It has been shown that, under aërobic conditions, the decomposition of cellulose in the soil

is almost entirely due to the activity of molds. Only under anaërobic conditions, which seldom exist in well-cultivated soil, do bacteria play an important part in this process. Also, many of the molds will produce ammonia from proteins more rapidly than the most active of the ammonifying bacteria. However, a large part of the material decomposed is used to produce more mold tissue and thus does not become available to other plants until after the death of the mold.

There is much still to be learned regarding the possibilities of producing chemical change on a large commercial scale by means of molds. The empirical application of molds in the manufacture of saké (a fermented drink) and soy sauce has been understood for centuries in the orient, though it is only recently that a scientific knowledge has been obtained regarding the reactions and organisms involved. About the middle of the nineteenth century it was discovered that gallic acid could be manufactured by the action of molds on tannin. A number of different varieties of cheese, such as Camembert and Roquefort, owe their peculiar flavor to molds. On the other hand, the ripening of hard cheeses such as Cheddar, Swiss, and Edam, is believed to be due to bacterial action without the intervention of molds.

In the present-day production of organic chemicals Aspergillus probably is the outstanding mold, not only because of its actual ability to do useful work but also because it is easier to handle. In the production of citric acid the sugar solution is placed in shallow pans, since the action takes place entirely on the surface of the liquid. By the end of the tenth day after inoculation with Aspergillus niger the fermentation is usually complete.

The mold Penicillium has been used fairly successfully to produce gluconic acid from glucose in small-scale operation. Recently, it has been shown that Aspergillus niger will give a greater uniformity of result when submerged in a rotary drum container under pressure. In this latter work it has been found that the rate of fermentation depends largely upon the factors which control the supply of oxygen available to the organisms.

Herrick and May, who have done much work in this field, write as follows. "Molds are temperamental, but so is human labor, and molds have their advantages. They do not sleep on the job; they work twenty-four-hour shifts; there is no strike, no turnover. All they need is infinitesimal quantities of the proper food, a comfortable home in a temperate climate and protection from their enemies and they will work for you uncomplainingly until their work is done." The same statements may be made with regard to bacteria and yeasts.

These authors also state, "Microbiological chemistry is the chemistry of the future. Most of nature's growth processes are catalyzed by the action of enzymes. When the chemist or engineer attempts to duplicate them he takes acres of ground, tons of machinery, the productive labor of hundreds of men to imitate what nature has done in the stem of the plant or the leaf of the tree; and too frequently he makes a bad job of it. When nature wishes to synthesize a product she takes a few elements from the soil, calls on the sun and air for aid and the work is done."

ACQUAINTING *the* UNDERGRADUATE *with the* CHEMICAL LIBRARY*

JOHN R. SAMPEY

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AT THE twenty-fourth annual conference of Eastern College Librarians at Columbia University last fall the accusation was made that the average college student graduates ignorant of everything except a few textbooks. The speaker preferring the charge did not single out any department or group of departments as more guilty than the others, but who has not heard the instructor in one of the physical sciences, when approached on the subject, seek to excuse the infrequent visits of his undergraduates to the library with the statement that there is more in one good scientific textbook than his students can master; or, if pressed further on the issue, take cover behind the old argument that his science classes have such long hours of laboratory work that there is little time left for the library. Some librarians, however, have a disconcerting way of checking on the reference work done by departments, and in many institutions of a liberal arts nature the allocation of funds is often influenced,

* Presented before the Division of Chemical Education at the ninety-third meeting of the A. C. S., Chapel Hill, North Carolina, April 13, 1937.

if not determined in large part, by the use the departments make of the library.

It may be launching the argument for more library work on a low plane to mention these departmental phases of the subject, but every teacher of first-year chemistry knows that there is another side. As brought out in this same conference of librarians, the greatest handicap of the college freshman is his lack of a reading knowledge in every field. The librarians explain the situation by asserting that the student's preparatory or public school gives him little but a hatred of poetry that he is compelled to learn by heart, while his high school earns a mitigated approval because they never made him learn anything there.

It is obviously futile to give a student with such limitations an acquaintance with the broader phases of chemical literature open to an undergraduate, or to expect the attempt in that direction to help him materially with the regular classroom and laboratory assignments, but for one with more native ability and the ambition to secure the best possible foundation for his professional career, there are few efforts that will yield larger dividends at this stage of his training.

Before suggesting how each of the fundamental undergraduate courses may make its own contribution toward a more intimate knowledge of the chemical literature by the preprofessional student, let us note how parallel reading assignments may enrich the cultural or pandemic type of first-year chemistry.

One of the avowed purposes of the cultural course is to give the student an appreciation of the growing library of popular science. To teach him to read discerningly and discriminatingly therein will prove a service of ever-increasing value. The writing of term papers and the searching out of material for projects are two time-worn methods of securing library work. More consistent parallel reading throughout the course may be secured by selecting a few definite references as each new subject is approached in the course, especially if some inducement is offered to hand in written reports on the same; required parallels usually prove a bore, but the offering of extra credit for a well-prepared report will stimulate initiative in the interested student, while it may be used to prod the indifferent to improve his class standing. The references range from whole books to newspaper clippings. The JOURNAL OF CHEMICAL EDUCATION offers the single richest source of material for the pandemic group.

Parallel reading assignments in the first-year preprofessional course will naturally be more restricted because of the mass of technicalities to be mastered at both recitation and laboratory periods. This situation makes it easy for the instructor and the class to fall victims to the evils of a one-textbook-course; nothing will prove more deadening to the intellectual life of the instructor, or lead the student to form more readily, consciously or unconsciously, provincial ideas and attitudes that will require years to correct. Moreover, no single text can claim to be superior in its treatment of every phase of the wide field covered in general inorganic chemistry; the experienced instructor knows when and where to guide the student to other texts. These references to other textbooks should not constitute the only parallel reading of the first-year course, for there are times when the grind of the theoretical and technical treatment should be broken with discussions from treatises written primarily from the historical and industrial points of view.

Undergraduate courses in analytical chemistry are designed primarily to test and develop the student's skill in laboratory procedure. Let the parallel reading assignments contribute toward this end. References that give additional confirmatory tests in the schemes of qualitative analysis will result immediately in the better informed student reporting more accurate analyses. In quantitative analysis the beginning student needs to read widely in the technic of the basic operations of gravimetric and volumetric analysis if he would keep his own mistakes in the laboratory to a minimum. One way of checking on this reading before the student is admitted to the laboratory is to require him to hand in answers to a set of questions on technic taken from a number of different reference works.

While stoichiometric calculations and theoretical topics are relegated to places of secondary importance in analytical chemistry, facility in handling the former is achieved only after a rigorous drill, while the latter offers an opportunity to broaden the student's foundation in general inorganic and physical chemistry. There are a number of mathematical helps for students of chemistry, and the undergraduate chemistry major will do well to make an early acquaintance with these. The problem page which has appeared in the JOURNAL OF CHEMICAL EDUCATION at intervals may not assist the young analyst to calculate the results of his own analyses, but it will give him something to aim toward in his mathematical preparation, particularly if he expects to enter the field of physical chemistry.

There is one other phase of library work that does have immediate practical value for the student of analytical chemistry. Mastering the art of elementary technic in quantitative analysis is so tedious and time consuming that the student who limits his knowledge to the experiments he can perform in one or even two years of laboratory work will have no appreciation of the wide scope of the science. Only by extensive reading in the many specialized fields of analytical chemistry can he hope to arrive at any fair appraisal of this branch which has been referred to as the handmaid of the science. Microchemistry, colorimetry, organic analysis, and technical methods of analysis are a few of the fields that are being worked intensively today. A glance at any of the issues of the *Analytical Edition* of *Industrial and Engineering Chemistry* will reveal others.

The average undergraduate chemistry major perhaps does less parallel reading for the elementary course in organic chemistry than for any other. He is so overcome by the mass of data to be committed to memory that he loses interest in all else, and well he

may for only a few recent texts make any serious effort to shift the emphasis from the factual to a consideration of the application of the underlying principles of atomic and molecular structure; this commendable departure on the part of these modern texts may be capitalized further by citing the student to additional references of interpretation of organic phenomena in terms of current concepts of valence. Another means of encouraging parallel reading in the introductory course in organic chemistry is to refer to modern industrial practices, a surprising number of which will be found to be at variance with the classical processes emphasized in the text.

Finally, the undergraduate course in physical chemistry offers unparalleled opportunity for reference work. Who does not recall spending long hours in the library seeking the interpretation of data collected in the physical chemistry laboratory? Or who does not have to seek continuously for more light from monograph and journal articles on such topics as the behavior of solutions of electrolytes and the ultimate nature of matter? Instructors in physical chemistry have demanded and received from the undergraduate more library work than can be claimed by teachers of any other division of the science.

In conclusion, the instructor who follows the instructions outlined for better acquainting the undergraduate with the chemical library can rest assured that his students will not come under the indictment made in the opening paragraph, but he may well entertain some fears for his own standing when the librarians see fit to set forth their next pronouncements.

The PRESENT HIGH-SCHOOL COURSE *in* CHEMISTRY—*A* PARADOX*

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CONSIDERING the universal touch of chemistry it would seem that the teaching of the subject, both secondary school and college, should merit very serious consideration. In these courses the students' valuable time is being consumed; results, good or bad, may follow which will either help or hinder them for a lifetime. As a basis for such a discussion one might ask three questions: Does the present high-school course in chemistry prepare primarily for college, or can it be said to aim specifically at training for life, or does it do both?

Judging by the textbooks in use the standard high-school course in chemistry and the first-year college or university course are still one and the same, with such modifications as a one- to two-year difference in age of the students seems to impose. Eleven of the standard high-school texts now in use range from four hundred to over eight hundred pages, while a like number of college texts run from five hundred to almost one thousand pages.

Comparing the two sets of books they disclose that the college course of first-year general chemistry is really a high-school course grown up, or rather the high-school course is a slightly simplified college first-year course.[1] That is, the subject matter treated in the two sets of books is identical, but the pages of the high-school texts are a little smaller, and usually the type is a little coarser. A glance at the table of contents shows that the chapter headings and subject matter in general are quite the same.

What has guided the authors in amassing the subject matter of these texts may be gathered from one preface which says: "All of the standard subject matter of chemistry, plus much additional material. . . . ." And it is all there: atomic structure, electron theory of valence, protons, neutrons, deuterium, and lo! the cyclotron. Then, too, we find Moseley's derivation of atomic numbers, lattice structure of crystals, monatomic hydrogen, the mass spectrograph—all are there; but I look in vain for pH. Evidently the guide in getting up a textbook for high school today is to leave nothing out—include it all.

That, it seems, is also the guide in writing a college text—to leave nothing out. So the books of today,

* Presented before the Division of Chemical Education at the ninety-fourth meeting of the A. C. S., Rochester, New York, September 6, 1937.

[1] S. R. Powers stated some pointed conclusions when [J. CHEM. EDUC., 2, 802 (1925)] he said, ". . . . . The course offered at the two levels [high school and college] are markedly similar. . . if a student takes the course in general inorganic chemistry in college, after having had the high-school course, which is often done, he is repeating almost all of it. . . . . This study affords a factual basis for the statement that the high-school course in chemistry is but an abbreviated college course."

both for high school and for college, become chemical cyclopedias,[2] whose indexes must name every fact and fancy that go to make up "all the standard subject matter of chemistry, plus. . . . ."

First let us clarify the question, what is the purpose of the high-school course in chemistry? The syllabus of subjects involved under the secondary-school curriculum for Minnesota states as specific objectives:

1. A thorough knowledge of elementary chemistry as such knowledge relates itself to good citizenship, social welfare, home and community life, commerce, the trades, and the professions.
2. An understanding of the interrelation of all sciences thus giving a broader appreciation and understanding of the world in which we live.
3. Training in scientific observation and thinking leading to the ability to make impartial comparisons and careful generalizations upon a sound factual basis.
4. Chemical knowledge which will contribute to individual and community health.
5. Vocational information which will assist a pupil to determine whether chemistry offers him a field for his life work.
6. Interests which may function in a more worthy use of leisure time.

That this is a highly pretentious, though idealistic catalog of aims and purposes, must be conceded. If they could be realized it would forever bar any doubt about whether chemistry is a cultural subject. A sympathetic understanding of the interrelations of all sciences with a resulting broader appreciation and understanding of the world; ability to make scientific observations and to draw conclusions on a sound factual basis; to be the possessor of knowledge that shall enhance public health; to have a foundation which shall assist a man in choice of a vocation; these are the earmarks of a cultured personality. No one shall accuse the sponsors of such ideals of low aim. However, the psychology and pedagogy, by which such elaborate objectives are to be realized, on the basis of the textbooks offered, have certainly not yet been put into practice. It should appeal to every unbiased person that for a youth of sixteen to eighteen years of age to memorize eight hundred pages of more or less unrelated facts and be expected to digest the subject matter so as to acquire "a thorough knowledge of elementary chemistry, as such knowledge relates itself to good citizenship, social welfare, home and community life, commerce, the trades and the professions"—it simply cannot be done. It is a superhuman task, that's all. The sad results complained of by university and college teachers of first-year chemistry are no doubt due to the fact that high-school chemistry teachers under the guidance of such objectives and threatened by such syllabi are face to face with the impossible.

Chemistry, more than most subjects, especially the way it is taught, relies greatly on the memory. Eight hundred pages of memorization is the task. College professors bewail the fact that students come to them with a credit in high-school chemistry. They go so far as to declare it would be better to enter the university without having had it. They claim that the students have not only failed to acquire the "thorough knowledge," as stated in the list of objectives, but in the struggle to memorize enough of the eight hundred pages to pass the examination, usually imposed by a higher authority than the high-school teacher, they completely lose sight of the citizenship aspect, the social welfare implications, the trades and professional relations of the subject.

Assuming that the Minnesota objectives are pretty close to the ambitions of any State Department of Education, or the New York Regents, or the "College Boards," the question becomes pertinent: Do the high-school texts of today or the high-school syllabi in vogue conduce to the realization of such lofty aims? As a matter of fact, is point one of the Minnesota objectives realizable at all, even under the best of circumstances?

What, for instance, has the structure of the atom to do with "good citizenship?" What has heavy hydrogen to do with "social welfare?" Where do Moseley's atomic numbers enter into "home and community life?" How can the law of equilibrium, the law of mass action, Le Chatelier's principle, the Avogadro number, in one hectic childhood year relate a high-school student's thinking to the "trades and professions?"

In other words the high-school course in chemistry is an anomaly, a paradox. It fails to conform to requirements, it pretends to do the impossible; it is self-contradictory. The present high-school course in chemistry is an outgrowth of the time when College Boards and University Regents dictated entrance requirements.[3] Then the next question may be: Does the present high-school course in chemistry prepare for college? Originally, no doubt, it was intended to prepare for college or university. The complete negation of that assertion, however, lies in the fact that colleges and universities do not accept a credit in high-school chemistry for advanced standing. No college or university allows the high-school student, with chemistry credit, to go into second-year chemistry. A great many of them do worse than that; they chuck those with credit into the same courses and sections with those who come without such credit, saying as they do

[2] POWERS, S. R., J. CHEM. EDUC., **2**, 802 (1925). "For the accomplishment of this (the second objective being to impart to the students a broad knowledge of the field of chemistry), the texts in use are veritable cyclopedias of chemical information. . . . . Much of the new knowledge has been added and much of the older books has been retained until the accumulated material sets a task for the high-school student which is, for them, nearly insurmountable. . . . .Results support the conclusion that the knowledge aim is very imperfectly accomplished."

[3] This statement is made by several authors. It is not easy to understand why Boards of Regents, or other lofty authority, should prescribe a course, issue a syllabus and assign examination questions, and then refuse to accept the students in university courses built on their prerequisite course. What is done now is to require a rigid adherence to a literal repetition of the course in college.

so that high-school chemistry is worthless. So in the first-year university chemistry course students with high-school chemistry are forced to sit through lectures dealing, chapter by chapter, with what their high-school text discussed; they are also compelled to do many of their high-school experiments over again. Such a procedure can be defended neither from the standpoint of psychology nor pedagogy.

Whatever the faults of our present high-school chemistry may be, it does not deserve the wholesale condemnation it gets from college men.[4] We, in common with the writers of college entrance requirements, and the authors of high-school texts are expecting the impossible, but it is adding insult to injury to treat the young people, coming with high-school chemistry credit, the way they are being treated. For a university professor to say that at the end of a quarter or at most a semester, those coming without chemistry credit *have caught up*, is a crass commentary on inefficiency of procedure. What has really happened is that the prepared students *have been held back* until the others have caught up.

Since high-school chemistry then, by the words and deeds of university and college professors, stands condemned as a failure—*it simply does not prepare for college*—are we sure that we can defend the course as a preparation for life? Those are worthy and idealistic aims stated in the Minnesota objectives, point one. High-school courses should relate themselves to good citizenship, they should bring to bear thorough knowledge on the problems of social welfare. There is much in chemistry that can serve to better conditions of our fellowmen and our instruction should be such as to throw light wherever possible on the puzzling problems of human relations. Home and community are first concerns. The high school has been called the people's college and its first duty should be to serve its constituency. The high-school course can and should outline clearly the difference between the trades and professions of the community. Indirectly the farmer, the carpenter, the garage mechanic, the service station attendant, the dentist, and the doctor are all working with chemical problems. Their interdependence and dovetailed relationships can be brought out in untechnical language, and in terms intelligible to all. In essence, the problems of the individual, the business concern and the community of today, are chemical problems.

The high-school course in chemistry fails to prepare for life when it essays to lay a slightly simplified but far too technical, abbreviated college chemistry course as a foundation for the needs of daily living.

Stated concisely, the failure of the high-school chemistry course is due to two main causes:

(1) It is too massive. We smother all our objectives under an avalanche of words, theories, and technical applications. We give the students a book of four hundred to eight hundred pages; in Europe the textbook for the same course is one hundred fifty pages European students master the subject so that it can be said that they know the elements of chemistry; our students flounder in a morass of theory, practical application, and a multi-myriad of concrete but unconnected facts. And then, when such a pupil arrives at college he is treated as if he had not had the high-school preparation at all.

(2) It fails in that the course starts out as if it expected to make chemists of all these boys and girls. Very seldom does one of them become a chemist.* Taking for granted that the average high-school graduate is the same person we meet upon the average walks of life we shall have to hunt far and long to find many who have retained a great deal about atoms and molecules, atomic and molecular weights, the electron theory, valence and formula writing, molecular composition and equations, ions and ionization, the multitude of nitrogen oxides, the host of halogen derivatives, the Periodic System, the formulas for benzene, carbolic acid, and aspirin, the composition of alloys, cement, and steels; the making of sulfuric acid, nitric acid, and ammonia; the solubilities of all the common salts and the chemistry of the complex ions. Only now and then does any one of these facts or phenomena protrude themselves into the uneventful life of the average high-school graduate.[5]

If it must be confessed that most of the subject matter of the present high-school course is useless lumber, how can we say that the course trains for life? If chapter after chapter is a separate task of memory only to be forgotten[2] as soon as examination has been weathered, how can we justify the course as a cultural influence?

If it be true that ninety per cent. of the examination questions asked by our standard college entrance boards are memory questions, wherein lies the scientific thinking, drawing of logical conclusions, and ability to make sound comparisons?

Several voices have been raised in the past in protest against present conditions. A. Schwartz is dissatisfied with the "abbreviated college course" forced on our high schools.[6] W. M. Jackson calls the high-school course a vest-pocket edition of the first-year college course. He says only twenty-six per cent. of those who took high-school chemistry and then entered college, went on with the subject in college or university. He pleads for "an appreciation course."[7] Robert Collier, Jr., writes: "The chief disadvantage lies in the fact that college entrance examinations still dictate and restrict the type of chemistry which high schools must

[4] GLASOE, P. M., "Residue of high-school knowledge utilizable in college chemistry," J. CHEM. EDUC., **10**, 571 (1933).

* The name chemist is, of course, very elastic. Taking manufacturing statistics for the government I ran across the name H. M. Nomen, Chemist. As I entered to record the statistics of his business I found that he concocted a sheep-dip according to a formula which he had taken from a book of recipes.

[5] POWERS, S. R., "How long do students retain chemical facts?" J. CHEM. EDUC., **2**, 174 (1925).

[6] SCHWARTZ, A., "A survey of Oregon high schools," *ibid.*, **3**, 817 (1926).

[7] JACKSON, W. M., "What sort of chemistry?" *ibid.*, **4**, 58 (1927).

teach; and until those in charge of secondary education can break away from the college requirements, little progress can be made."[8] Gerald Wendt: ". . . .the ever-growing protest against the course in chemistry as now offered for students who are not specializing in the subject. . . . . There is substantial agreement among critics, administrators, teachers, students, and alumni, and public men deplore the lack of any tangible benefits to the vast majority of students who take a year of chemistry."[9] Wendt quotes to good effect President Nicholas Murray Butler's:[10] "Must science go the way of the classics?" Then he continues: "It has been shown that ten per cent. or less of students who take the first-year course in chemistry follow it with any other work in the subject. Tests on 10,000 students have shown that the information imparted to the students in our present course is very soon forgotten."[11] Wendt proceeds to outline a course both scientific and cultural, especially for the college level.

While Dr. Bancroft[12] intended his course in Pandemic Chemistry for the universities and colleges an elementary course in the same for high schools is even more called for. Chemistry students of our high schools by the tens of thousands are being given the highly technical memory course which in reality prepares only for scientific careers. The great majority of them do not enter college; of those that do only a small per cent. continue college chemistry.

Such a course should be cultural rather than purely scientific. It should be an appreciation course, a humanized course in which the relation of chemistry to the daily life of men should be stressed rather than the relation of atoms and molecules to composition and reactions. It goes without saying that this will be a course *about* chemistry. The course about chemistry can be made so romantic, so thrilling, so vitally sympathetic with life and with science that boys and girls will carry with them a real knowledge of what chemistry is and a friendliness for it that will redound greatly to the popularity of the subject among our people.

Such a course will prepare both for college and for life. It will not be repeated in college. It brings to college a generation of intelligent boys and girls, trained to appreciate, enjoy, and evaluate also the general field of the other sciences. It can be made a *real college preparatory course.*

[8] COLLIER, ROBERT, JR., "A new type of chemistry," J. CHEM. EDUC., **8**, 2214 (1931).
[9] WENDT, GERALD, "The problem of the one-year course," *ibid.*, **8**, 270 (1931).
[10] President's Report, Columbia University, **1925.**
[11] POWERS, S. R., *loc. cit.*
[12] BANCROFT, W. D., "Pandemic chemistry," J. CHEM. EDUC., **3**, 396 (1926).

APPLICATION *of* CERIC SULFATE *to the* DETERMINATION *of* ARSENIC *in* PARIS GREEN *and* LEAD ARSENATE

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RECENT investigations (*6, 13, 14*) have shown that ceric sulfate is a very satisfactory standard oxidizing agent in a wide range of analytical procedures. It has a number of decided advantages over the more commonly known and used potassium dichromate and permanganate. In particular, a number of workers (*4, 9, 11, 13*) have indicated that it quantitatively oxidizes arsenic in hydrochloric acid solution from the trivalent to the pentavalent condition.

In the present work a study has been made of the application of ceric sulfate to the determination of arsenic in Paris green and lead arsenate, and the results have been compared with those obtained by titration with standard iodine solution. The former official method of the Association of Official Agricultural Chemists (*2, 5, 10*), in which the arsenic is reduced with potassium iodide before titration with standard iodine, cannot be used with ceric sulfate because the latter oxidizes potassium iodide to free iodine. However, the official distillation method (*1*), wherein the arsenic, reduced to the trivalent condition by hydrazine sulfate, is distilled as arsenic trichloride before titration, does not involve this difficulty.

PREPARATION OF SOLUTIONS

Ceric ammonium sulfate was used rather than ceric sulfate because it is more easily dissolved. It was made up as a 0.1 *N* solution in a 0.05 molar sulfuric acid solution as directed by Smith (*6*). Occasionally some grades of the salt may require additional acid for solu-

tion. The solution was standardized against arsenic trioxide of known purity which was distilled according to the official method (*1*). The stability of ceric sulfate solutions has been pointed out by Furman (*3*) and by Willard and Young (*12*). Standardizations carried out at intervals over relatively long periods of time confirmed their observations that the solution was stable for forty weeks.

Hydrazine sulfate reagent (*1*) was prepared by dissolving 20 g. of hydrazine sulfate and 20 g. of sodium bromide in 1000 ml. of 1:4 hydrochloric acid. The equivalent amount of potassium bromide was found to work equally as well.

TABLE 1
RESULTS OBTAINED FOR PARIS GREEN BY THE CEROMETRIC METHOD

Sample No.	KI Reduction Method As_2O_3 by iodine, %	Distillation Method As_2O_3 by ceric sulfate, %	Distillation Method As_2O_3 by iodine, %	Difference between ceric sulfate and iodine distillation methods, %
1	63.70	63.63	63.62	+0.01
2	49.17	49.12	49.21	−0.09
3	51.08	51.10	51.02	+0.08
4	52.23	52.32	52.28	+0.04
5	57.36	57.31	57.31	0.00
6	57.63	57.63	57.63	0.00
7	57.94	57.92	57.99	−0.07
8	57.51	57.47	57.50	−0.03
9	57.33	57.30	57.32	−0.02
10	41.36	41.40	41.39	+0.01
11	56.70	56.74	56.69	+0.05

Iodine monochloride, the catalyst (*9*) for the reaction between ceric sulfate and arsenic trichloride, was prepared as follows (*7*). Ten g. of potassium iodide and 6.74 g. of potassium iodate were dissolved in 90 ml. of water, 90 ml. of concentrated hydrochloric acid were added, and the solution stirred well. To the orange-colored solution 5 ml. of chloroform were added and, after stirring, any red color in the chloroform was removed by adding drop by drop 0.005 molar potassium iodate solution, finally balancing with a drop of 0.01 molar potassium iodide solution. The final color of the chloroform must be very faint. Ten ml. of this solution were diluted to 1000 ml.

The indicator, *ortho*-phenanthroline ferrous complex (*8*) was obtained, already prepared as a 0.025 molar solution, from the G. F. Smith Chemical Company. It may also be made by dissolving 6.95 g. of crystalline ferrous sulfate in 1000 ml. of water, adding 14.85 g. of *ortho*-phenanthroline monohydrate, and stirring until solution is complete. One drop of this solution serves for a single titration in a volume of 100 = 150 ml.

PROCEDURE

As much as possible of a 1.5-g. sample of Paris green or dried lead arsenate was transferred with a spatula from the counterpoise watch glass into a 250-ml. distilling flask and the remainder was carefully washed into the flask with 50 ml. of hydrazine sulfate reagent. The solution was then distilled with concentrated hydrochloric acid according to the official method (*1*) of the Association of Official Agricultural Chemists. The most satisfactory time of distillation is about three hours. Shorter periods gave high results. The distillate was made up accurately to 1000 ml. at room temperature. To a 200-ml. aliquot of this solution in a 500-ml. Erlenmeyer flask 25 ml. of concentrated hydrochloric acid was added and the mixture was heated to 50°. Then 5 to 7 ml. of iodine monochloride and one drop of *ortho*-phenanthroline ferrous complex indicator were added and the solution was titrated with standard ceric ammonium sulfate. The color change is from pink through orange to practically colorless. A one-minute endpoint was taken. It was found advisable to run a blank titration and make any necessary correction therefor. For comparison another aliquot of the distillate, after neutralization with sodium bicarbonate, was titrated with an iodine solution that had been standardized against distilled arsenic.

The results of the determination of arsenic in eleven samples of Paris green and five samples of lead arsenate are shown, respectively, in Tables 1 and 2, which also include the figures obtained by titration with standard iodine according to both of the Association of Official Agricultural Chemists methods (*1*, *2*, *5*, *10*).

DISCUSSION

Titration with ceric sulfate is capable of giving results for arsenic in Paris green and lead arsenate which are within ±0.10 per cent. of the values obtained by the official iodometric method. Results may be duplicated on the same sample with a precision of about ±0.05 per cent. The standard ceric solution is very stable and thus has a decided advantage over iodine solution, which must be restandardized very frequently. Since the indicator, *ortho*-phenanthroline ferrous complex, is not subject to decomposition as is starch solution, it may be kept indefinitely. In addition the endpoint is more easily detected.

TABLE 2
RESULTS OBTAINED FOR LEAD ARSENATE BY THE CEROMETRIC METHOD

Sample No.	KI Reduction Method As_2O_3 by iodine, %	Distillation Method As_2O_3 by ceric sulfate, %	Distillation Method As_2O_3 by iodine, %	Difference between ceric sulfate and iodine distillation methods, %
1	24.82	24.77	24.82	−0.05
2	9.16	9.22	9.25	−0.03
3	31.58	31.50	31.49	+0.01
4	42.42	42.51	42.47	+0.04
5	14.64	14.59	14.69	−0.10

SUMMARY

Ceric ammonium sulfate has been shown to be a satisfactory standard oxidizing agent when used instead of iodine in the determination of arsenic in Paris green and lead arsenate by the official distillation method of the Association of Official Agricultural Chemists.

The advantages of the cerometric method over the iodometric method have been indicated.

ACKNOWLEDGMENT

The writers wish to express their sincere appreciation to L. E. Stevenson, now with the Weyerhauser Company, Longview, Washington, for the valuable preliminary work he did on cerometric-arsenic titrations while a student at Oregon State College.

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A CONVENIENT LECTURE APPARATUS FOR GASES

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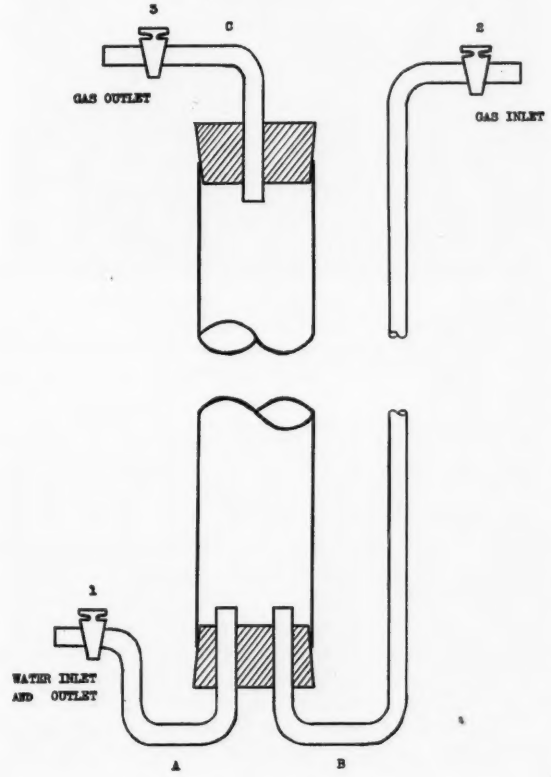
RECENTLY, because of the need of a safe carbon monoxide collector, I constructed the following type of apparatus which, in the opinion of several others, is more suitable than the pneumatic trough for certain experiments.



A long glass cylinder of large diameter is secured. To the top and bottom, respectively, a one-hole stopper and a two-hole stopper are fitted. Into the bottom stopper a small bent glass tube (*A*) and a long tube (*B*) are introduced. *B* is as high as the cylinder so that, when the apparatus is filled with water, no water can be forced into the generating chamber. Into the top, a bent tube (*C*) is introduced. *A* serves as a water inlet and outlet, *B* as the gas inlet, and *C* as the gas outlet.

To prepare the apparatus for use, water is run in through *A* until the apparatus is completely filled. (To collect gases soluble in water, other liquids might be used, although this is not as convenient.) Then the stopcocks, 1, 2, and 3, are closed. To collect the gas, stopcocks 1 and 2 are opened, thereby permitting the water to run out and the gas to enter. The gas literally rushes into the vacuum formed by the falling water. Its passage through the water partially purifies the gas.

To obtain the gas for burning or other purposes, it is merely necessary to open stopcocks 1 and 3 and run water into the system. To mix the gas with air or some other gas, the apparatus is only partially filled. Then tube *C* is connected to the gas source or left open to the air, stopcocks 1 and 3 opened, and the water permitted to run out. If the cylinder is graduated, known volumes of gases can be forced out or mixed.

Another feature of the apparatus is its safety in combustion experiments. If an explosion does occur, the rubber stoppers are simply forced out and the cylinder remains intact.

The CHEMIST *at* WORK

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XX. SANITARY CHEMISTRY AS A VOCATION

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Edward Scott Hopkins is a native of Maryland. He graduated from Milton College and later attended Johns Hopkins University and the Universities of Maryland and Georgetown.

In 1923 Mr. Hopkins entered the service of the city of Baltimore as Principal Sanitary Chemist in its Bureau of Water Supply. Just recently he has become Acting Filtration Engineer in the same bureau. He has been an officer in the Sanitary Reserve Corps, lieutenant for twelve years and captain since 1936.

He is a member of the American Chemical Society, former chairman of the Maryland Section, treasurer and later chairman of the Water, Sewerage and Sanitation Division. He is now president of the Maryland Water and Sewerage Association. He is the author of various articles and books dealing with different phases of water purification and control and sanitation.

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Chemistry in sanitation resolves itself into the control of many processes, as this subject includes water purification, sewage disposal, and trade waste discharge. In most instances utilization of stream waters is involved. With the growth of urban civilization these subdivisions are interlocking, forming a composite science.

Those individuals charged with the administration of the many types of treatment plants must possess a broad technical background, together with long experience in the field. Efficient management of such works necessitates a knowledge of chemistry, bacteriology, and engineering. Plant design is fundamentally based upon principles of chemical engineering, and their operation is determined by bacteriological testing.

It is expected of the trained laboratory staff, who perform the routine chemical and bacteriological tests, that they continuously keep abreast of their science by technical reading, society memberships, and further study. The usual undergraduate college training is acceptable as prerequisite of a satisfactory background. If special training has been given, the chemical personnel should be qualified in colloidal and physical chemistry. Organic chemistry is of relative importance in this field and biological chemistry, as usually taught, has practically little value. A general course in bacteriological principles with detailed application to sanitary problems is sufficient background for the average routine investigator. It frequently happens that a particular individual who has developed as a specialist in a given phase of the field, will become recognized as an authority in that branch. This situation will cause a certain plant or laboratory to stand out as an example for others interested in that portion of the general science.

It cannot be questioned but that chemical engineering, using as its definition the application of engineering principles to chemical problems, is the fundamental course needed for plant control. The necessary practical engineering can, however, be acquired by the chemically trained man through experience or he can supplement his previous training with formal selected courses. A present outstanding handicap of the science is the lack of chemical advice or training in the design of many existing plants. It must be said in justice to the civil engineering profession that they did the best possible with meager fundamental chemical information. It is of interest to note that these conditions are being eliminated in present-day design.

FIGURE 1.—INTERIOR VIEW OF THE OLD FILTER PLANT. THERE ARE THIRTY-TWO UNITS EACH HAVING A CAPACITY OF 4,000,000 GALLONS PER DAY. TOTAL CAPACITY BOTH PLANTS 240,000,000 GALLONS PER DAY

The object of water purification is to produce a commodity having a palatable taste, without odor,

taste, turbidity, and free from disease organisms. The principles involved are natural sedimentation in large reservoirs, coagulation by chemical treatment, sand filtration, disinfection by physical or chemical agents, and taste removal by adsorption. A separate phase is

FIGURE 2.—INTERIOR VIEW OF NEW FILTERS, MONTEBELLO PLANT, BALTIMORE, MARYLAND. THERE ARE TWENTY-EIGHT DIFFERENT UNITS, EACH HAVING A CAPACITY OF 4,000,000 GALLONS PER DAY. EACH UNIT COMPRISES EIGHT OF THE RECTANGULAR OPENINGS. *Courtesy of the Department of Public Works, Bureau of Water Supply, Baltimore, Maryland*

hardness reduction by chemical precipitation or base exchange phenomena.

As routine, coagulation control necessitates frequent determination of turbidity, pH, color, alkalinity, and hardness. The same is true for the softening process. Disinfection requires frequent testing of the agent utilized, commonly chlorine. This is determined by either the starch-iodide or *ortho*-tolidine methods. To facilitate service to consumers analysis for iron, manganese and dissolved oxygen are made, the purpose being to prevent economic loss through the staining of clothes when laundering, killing of gold fish, and to assure a pleasant tasting water. Complete analysis of the mineral constituents is in constant demand for information relating to generation of steam. Testing of the materials used in the purification process for available purity is an important task.

The efficiency of the filtration and disinfection processes is based upon bacteriological tests. They are frequently made, samples being collected every few hours. The B Cole-Aërogenes group of organisms is used as the index of sanitary purity. Inoculation of at least five lactose broth tubes per sample with additional plating upon differential media, such as eosin-methylene blue agar, is routine procedure. If a count of the general organisms is to be made additional plating upon peptone agar is carried out. Manufacture of media is a highly technical job requiring personnel. Enumeration and identification of algae and other species of microorganisms is a daily task.

The simplest form of sewage disposal is to discharge it into a stream of sufficient capacity to provide dilution of great magnitude. Under these conditions aërobic bacterial action occurs with ultimate stabilization of the waste. The concentration of peoples in urban centers, together with the discharge from industrial activity, has made necessary the use of more complex methods.

The initial step in each instance is to screen out the coarse liquids then passing to sedimentation, with or without chemical precipitation. In many instances final discharge of the liquid is through trickling filters

FIGURE 3.—CHLORINE WEIGHT ROOM—MONTEBELLO FILTRATION PLANT, BALTIMORE, MARYLAND

made of coarse gravel, into a convenient stream. Chlorination of this effluent to reduce putrescibility and to control odors and the presence of flies in these systems is of frequent occurrence. Treatment of the settled material or sludge is carried on by various methods. It may be digested in separate tanks or activated with air or treated by one or more special patented processes. Utilization of the hydrocarbon gases obtained from sludge digestion is a new development.

Control methods require frequent determination of suspended solids with additional testing for total and suspended solids. The suspended solids are, of course, an approximation of the quantity of material retained in the settling tanks. Ammonia and total nitrogen tests are used to obtain knowledge as to the decomposition and stabilization rate of the sewage. The bio-oxygen demand and methylene blue tests are used to determine the stability of the sewage effluent being discharged into the water course. These tests require considerable skill and experience. In addition, grease, nitrogen as nitrates, pH, chlorides, and chlorine are

routine tests. Bacteriological control is usually limited to the presumptive tests for members of the colon group together with the counting of the acid-forming organisms and the total number present. In conjunction with sludge conditioning by chemical methods, the various tests needed to control coagulation and to determine the sludge characteristics are made. Lime is used extensively to maintain correct reaction balance. Trade waste disposal ranges from controlling the discharge of a small creamery or canning factory to that of the largest industries, such as oil refineries, steel plants, and so forth. The problems are many and varied and can only be solved by coöperative laboratory research on the part of the industry and sanitary authorities concerned. In this type of work a broad, technical, trained background is especially valuable.

It is easily shown in the above discussion that the tasks of the plant operator are many and diverse. He must decide and initiate the necessary study upon which the routine tests are laid. Under his direction are instituted new methods of testing or of technical operation. It is frequently necessary to make a complete study of the water-course involved for the checking of pollution and to inaugurate methods for their elimination. Many conditions of this type are removed at the source by the plant manufacturing the product through a change in their processes. The waste product is frequently converted into a profitable material. Such recovery is a major phase of trade waste disposal chemistry. It is seen that bacteriology, chemistry, and chemical engineering must combine to meet these requirements. Only as the laboratory staff is reasonably expert, and when its work can be absolutely relied upon, will it be possible to successfully solve many of these problems.

[Dr. Hopkins calls attention to the comprehensive report covering the details of training for water and sewage plant operators which was published in *Industrial and Engineering Chemistry, News Edition*, **12**, 389 (1934). He would amplify these suggestions by emphasizing the importance of analytical chemistry—one semester of volumetric and gravimetric is inadequate. His last sentence regarding personal traits is, "Get a complete understanding of the daily school task; do not be one who allows studies to accumulate prior to examinations."]

XXI. RESEARCH IN THE MANUFACTURE OF SPECIAL LUBRICANTS

ROBERT C. WILLIAMS

The Ironside Company with which the writer of this article is associated was incorporated in 1893. They are engaged primarily in the manufacture of special lubricants for industrial purposes. Although a small company, they have representatives in both Canada and France. The writer is the only chemist connected with the organization.

Robert C. Williams received the A.B. and A.M. degrees from Oberlin College and the Ph.D. from Leland Stanford University. Before accepting his present position he was connected with the Battelle Memorial Institute of Columbus, for about two years. His publications deal with catalysis colloids, and lubrication.

At present he is a Councilor from the Columbus Section of the American Chemical Society.

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The present position of the writer is with a relatively small manufacturer of special lubricants. This connection followed the termination of a project sponsored by his employers at an industrial research institute. At the institute he conducted research which dealt with the study and development of wire-drawing lubricants. This and other work pertaining to lubricants was continued on moving to this laboratory six years ago. The writer is the only chemist with this company and as such enjoys a unique position. This type of connection, *i. e.*, with a small manufacturer, has been and will continue to be a fertile field for chemists. It is certain that similar opportunities have been overlooked in the past by prospective job-holders who eyed jobs with large concerns with highly populated chemical laboratories.

Fortunately, as far as this position is concerned, there is little routine work which requires one's attention and therefore one's efforts are largely of a developmental nature. Most of the ground work on wire-drawing lubricants was done at the institute and since that time the writer has been keeping in touch with actual tests made on newly developed products and also doing occasional trouble shooting in the wire mills of regular customers among which are many of the best-known wire manufacturers.

In this laboratory the wire-drawing lubricants are largely of the so-called soluble type, that is, aqueous emulsions of oils, fats, and other unctuous materials. Among the factors which have been considered and which are interrelated are the nature and quantity of the emulsifying agent and dispersed lubricant, pH and stability of the system, dirt, and metallic settling properties of the emulsion, effect of the lubricant on the

wire, ease of cleaning the wire, effect of the temperature attained in practice and the effect of the physical properties, such as melting point, of the dispersed lubricant.

One of the most interesting and valuable phases of the developments which have been made is that of the study of the effect of the pH of soap solutions on their behavior when used in the drawing of copper wire. It was found that when the pH was raised high enough to repress the hydrolysis of the soap completely (so that fatty acid did not exist in the solution) the solution was no better than pure water as a lubricant. This laboratory finding is of considerable importance in practice.

A day in the laboratory might be like this: the early mail brings a request from one of the company's representatives for a recommendation for the proper grade of lubricant to be used in a new wire mill. This mill draws various sizes of fine wire in a battery of machines with a finishing speed of five thousand feet per minute. Each machine is equipped with its own tank which holds one hundred gallons of lubricant solution. The rolls and dies are sprayed with the solution instead of running immersed in it. Experience in other mills under similar conditions indicates that a grade of lubricant possessing the highest detergent action is desirable to keep these high speed rolls from gumming. (High temperatures, relatively speaking, must be taken into account.) These conditions are a guide in making the initial recommendation for this mill.

After (or perhaps before) deciding upon the grade best adapted for this job, a representative from a well-known chemical manufacturing concern calls to tell about his new lubricant addition agent which he says is a great development for use in lubricants in the transmissions and differentials of automobiles. This laboratory agrees to test it for load-carrying capacity on an experimental device for that purpose and to compare it with the lubricants which it has developed.

For several hours experimental work is conducted on a slow speed wire-drawing machine to determine the relation of the physical properties of various solid substances to lubricating value.

The executives of the company have a decision to make relative to the purchase of a tank car of an animal fat or a car of a certain hydrogenated oil. The writer is called in and the specifications of each are discussed. Factors, both economic and chemical, are considered. A decision is made after weighing the evidence for and against each fat.

Time remains to plan and start some relatively simple corrosion tests in connection with a roller bearing installation where one of the plant's products has been proposed and where water cannot be positively excluded.

Occasionally minor problems in plant practice command attention. For example, the study of lime from different sources used in the production of lime soap for greases was worth while. Some limes produced soap with considerable less inert and insoluble impurities.

There is no closed season on hunting new processes or products which may even be somewhat away from the regular line of products. For example, there was a demand for the development of an adhesive to be sprayed on a fibrous material which is used to catch dust in air-conditioning equipment. Some exacting properties were required. This development has resulted in a profit which was very welcome during the past four years.

There are a few drawbacks in general to a job such as has been described. One is the lack of daily association with other chemists. Therefore, one looks forward with pleasure to the local and national meetings of the American Chemical Society. Though this laboratory is fortunate in having desirable library facilities, some may be lacking in this respect. With the good fortune of having executive officers who are somewhat broadminded, an able chemist should win quite satisfactory compensation.

XXII. BIOCHEMICAL RESEARCH

MARJORIE P. BENOY

In 1926 the Cancer Research Laboratory of the University of Pennsylvania first came into existence, under the directorship of Dr. Ellice McDonald. In 1935 it changed its name and affiliation, becoming the Biochemical Research Foundation of the Franklin Institute. The foundation has three objectives:

1. *Study of the processes of disease from a chemical point of view.*
2. *Study of new organic chemical compounds with regard to their therapeutic, medicinal, and beneficent values.*
3. *Study of longevity and the diseases of age, with the hope of prolonging the span of life.*

There are three departments—chemistry, physics, and cytology—and at the present time there are fifty-one people on the staff. The work of the foundation includes

besides the tissue respiration studies, much work with enzymes, an investigation of blood proteins, a study of purines in their relation to necrosis of the liver, and various bacteriological investigations. The physics department is now constructing a cyclotron, by means of which artificially radioactive substances will be made available for biological study.

The apparatus used in the respiration studies is the culmination of a steady development in micro-manometric apparatus, carried out at Cambridge University by Dixon and Keilin, in Germany by Warburg, and by other workers. Dr. K. A. C. Elliott, who received his undergraduate training in South Africa, and went to Cambridge for graduate study, was just on the point of leaving England for America when the new apparatus was invented. He brought it here with him, perfected the technic of using it, and made the first extensive application of it in this work.

Miss Benoy's contribution has been confined to the micro-analytical determinations on the tissue and the medium in which it was held, along with the development of such methods.

Miss Benoy did her undergraduate work at Denison University and received her Ph.D. degree from The Ohio State University. She has been Instructor in Chemistry at Kansas State Agricultural College, Associate Chemist, Experiment Station Staff, Stillwater, Oklahoma, and Special Research Analyst, Battelle Memorial Institute.

The results of her research have been published in the JOURNAL OF THE AMERICAN CHEMICAL SOCIETY *and* THE BIOCHEMICAL JOURNAL.

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Although the Biochemical Research Foundation of the Franklin Institute stands committed by its present program to the study of pathological processes in general, at its inception in 1926 the laboratory was solely interested in cancer, and that particular disease continues to occupy an important position in the interests and studies of the staff. Dr. Ellice McDonald, founder and director, believed that progress against cancer could only be made when more was known about the chemistry and physics of the cancer cell and the medium in which it thrives. If it were clearly understood in what ways this cell differs from the normal cell, and what causes it to differ, it might be possible to suggest how it could be restored to normal or caused to die and disappear.

Cancer is one of our most deadly diseases, and its incidence has been increasing for some years past. There are only two available methods of treatment: radiation and surgery; and these can only be applied when the disease is localized. About ten per cent. of the cases, as they come, can be cured at the present time. These facts show the importance of finding a new treatment, especially one which can be applied when the disease is widespread throughout the body, as it frequently is.

The fundamental thing which characterizes the cancer cell is its power of reproducing other cells like itself at a rapid rate. In normal adult tissue, new cells are only formed as old ones need to be replaced. And so bones, muscles, and organs retain approximately the same size throughout adult life. Sometimes a cell runs amuck: it begins subdividing and forming new cells which are not needed. Each new cell continues subdividing and forming more new cells until there is quite a colony of these, quite a mass of tissue, for which the body appears to have no need. Such a growth can take place in almost any part of the body. The new cells will resemble those of the tissue in which they arise, without being identical with them. This mass of new and somewhat different cells constitutes a tumor. In time, groups of these cells will be carried away in the blood stream or the lymph, lodge some-

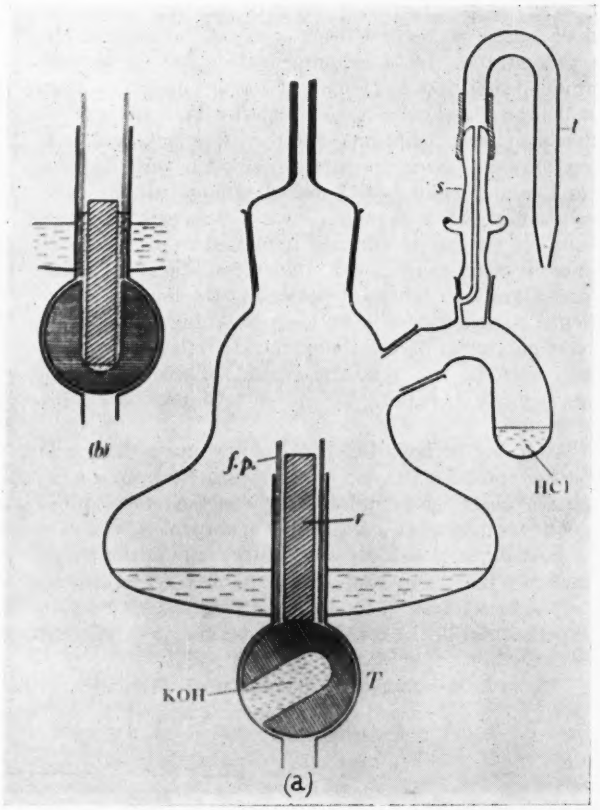


FIGURE 1.—DIAGRAM OF THE DIXON-KEILIN MANOMETER VESSEL
T—large stopcock containing cavity for holding KOH solution.
r—glass rod which falls downward when *T* is turned, displacing KOH solution.
f.p.—filter paper roll.

where, and set up a new colony of rapidly reproducing tissue: and so the disease may spread to various parts of the body. If we could take from these cells their abnormal power of reproduction, we could end cancer.

In this mad, almost unordered growth, large amounts of energy must be used up. Glycogen is the form in which carbohydrate is stored in the body for future use. Normal cells, making use of it as a source of energy, split it into lactic acid, burn a small part of the latter into carbon dioxide and water, and use some of the energy obtained to resynthesize the remaining lactic acid back to glycogen. Cancer cells, on the other hand, like careless spendthrifts, ruthlessly tear the glycogen apart, forming large amounts of lactic acid which they make no attempt to reclaim. Here is a chemical difference between cancer cells and normal ones which presents a point of attack for chemical study. Such a study is being made in this laboratory by the author in collaboration with Dr. K. A. C. Elliott.

Tissue can be taken from an animal's body immediately after death, cut in thin slices and immersed in a nutrient solution of approximately the same composition as blood serum and, if the temperature is favorable, the cells which are not injured during the slicing will continue to live, very much as they did in the animal's body. Each transplanted cell is like a well-equipped factory with its store of enzymes, and it will go on taking up oxygen if that is available, attacking carbohydrates, which it finds in the surrounding medium or still in storage within itself, to obtain energy, and giving off carbon dioxide. The slices must not be too thin or too large a proportion of the cells will have been injured in the preparation; and they must not be too thick either, or the innermost cells will die through the inability to get their food and oxygen under the make-shift experimental conditions which can be set up. A general description of an experiment follows, accompanied by pictures of the equipment used in studying tissue slices.

Two little flasks of exactly the same size are connected with a U-shaped tube containing liquid, which acts as a manometer. In each flask are placed 3 cc. of the nutrient medium, and between 0.1 and 0.2 g. of tissue slices. The whole system is filled with gas containing 95 per cent. oxygen and 5 per cent. carbon dioxide and is allowed to adjust itself to atmospheric pressure, then the stopcocks are closed. If an anaërobic experiment is being carried out, 95 per cent. nitrogen and 5 per cent. carbon dioxide are used. The flasks stand in a water bath at 38°C. Now, if hydrochloric acid is introduced into the left-hand flask (which shall be called L-flask to distinguish it from the right-hand one or R-flask), the tissue in that side will be killed and all physiological action will stop on that side.

The introduction of the acid is managed very efficiently: a little side tube *A* contains just the right amount, and by turning it half around at its ground glass connection, the acid tumbles in and stops further action. For ninety minutes the tissue in R-flask is left to go about its life processes. It uses up oxygen, gives off carbon dioxide, and forms other substances which remain in the solution and are discovered later. During this time the column of liquid in the connecting manometer tube will move as the pressure in R-flask changes, while, of course, the pressure in L-flask has no reason to change. After ninety minutes the manometer reading is recorded and hydrochloric acid is dropped into R-flask to kill that tissue and stop its action. Again the pressure in R-flask will change because the acid liberates all the carbon dioxide from the bicarbonate in the nutrient solution, and again the manometer reading is taken.

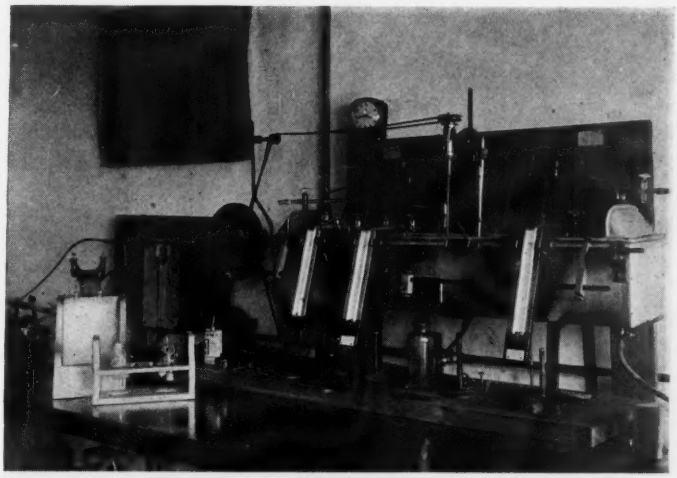


FIGURE 2.—THE DIXON-KEILIN MODIFICATION OF THE BARCROFT DIFFERENTIAL MANOMETER

Now in a very interesting way, the carbon dioxide is absorbed from each flask so that another manometer reading may be obtained which shows how much oxygen was used up in R-flask. The large stopcock, *B*, has a small cavity in it, large enough to hold a few drops of strong potassium hydroxide solution. All this time this alkaline solution has been carefully closed away from this contact with the interior of the flask. Now the stopcock, *B*, on each flask is turned and a small piece of glass rod, which has been supported in the cup, *C*, falls down forcing the potassium hydroxide solution up into the cup, *C*, where it comes in contact with a roll of filter paper which soaks it up; the moist alkali-soaked surface of the paper sticking up into the atmosphere of the flask provides a very efficient absorbent for removing carbon dioxide.

Without going into the calculations, it will suffice to say that these three manometer readings make it

possible to determine carbon dioxide used up, carbon dioxide produced, and also the amount of other acids produced, such as lactic, which set free carbon dioxide from the buffer of the nutrient solution. These data alone give important insight into the way in which the tissue cells are acting.

At the end of the experiment, the tissue slices are removed from the flasks, washed off, dried and weighed, so that all calculations can be based on dry weights of tissue. Then the solution from each flask is made up to 25 cc., and aliquots taken for careful determination of lactic acid and pyruvic acid, glycogen, and sometimes acetaldehyde. The data obtained by chemical analysis give further information about the behavior of the tissue.

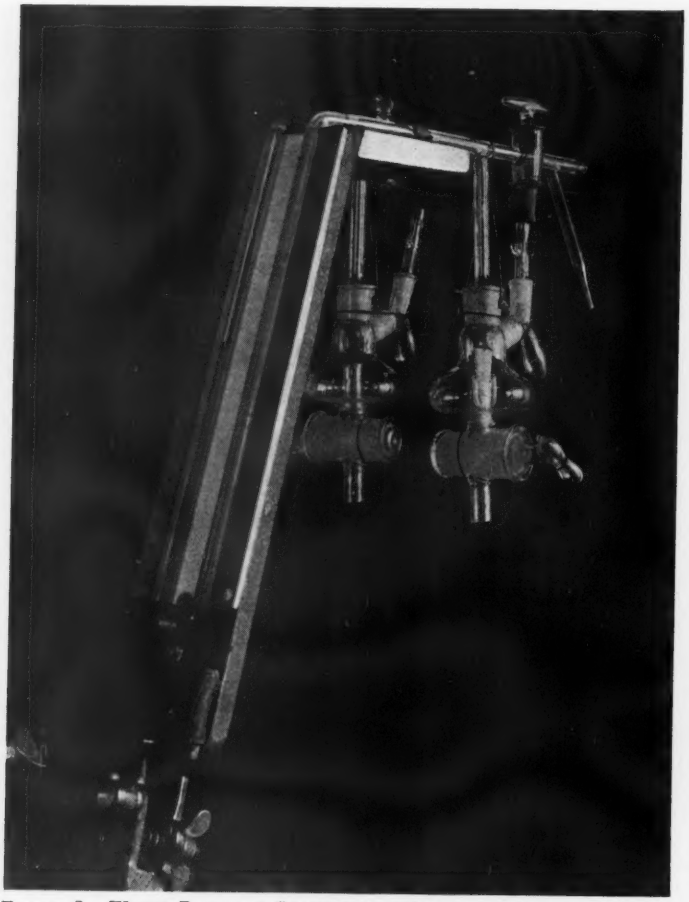
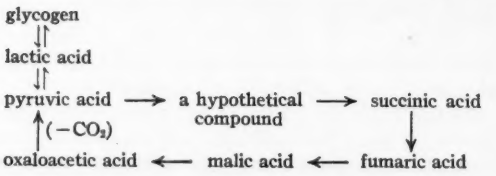


FIGURE 3.—WATER BATH AND SHAKING AND GASSING APPARATUS FOR USE WITH DIXON-KEILIN MANOMETERS

It was stated above that cells decompose glycogen into lactic acid and carbon dioxide, but the process is not believed to be a simple one. Muscle, kidney, and other tissue, for instance, seem to make use of a cycle like this:



In studying tumor tissue, this diagram is kept in mind. Tumor cells do not glycolyse just like normal muscle cells, but their scheme will bear some resemblance to the one given above; it may have some steps left out or new ones inserted. It is hoped that these experiments with the little flasks and slices of tissue will give much information about tumor cells. Four pairs of flasks are usually run at the same time. Into each is introduced the same amount of moist tissue slices and of nutrient medium. To the first pair nothing else is added. To the second pair, in equal amount on each side, is added sodium lactate; to the third pair, sodium pyruvate; to the fourth pair, sodium succinate. Then observations are made as to whether these additions stimulate the activity of the tissue or depress it. Those substances which stimulate, and which disappear from the solution during the experimental period, are considered possible intermediates in the glycolysis cycle. In succeeding experiments additions are made of malate, fumarate, and oxaloacetate, and of other substances which might be thought of as possible intermediates, and the effects observed. To get away from chance variation, it is necessary to make a number of runs under each set of conditions, using fresh tissue from different animals. For purposes of comparison, similar runs will be made on various kinds of normal tissue.

Eventually this procedure should give some kind of picture of the mechanism by which tumor cells degrade carbohydrates; and that will be just that much more information on an important and little understood subject.

This work, of course, requires great attention to detail. Tissue must be prepared quickly and very carefully. All measurements into the two flasks must be made with great care, all the more so because the amounts of materials used are so small. Even the greasing of the various ground glass surfaces must be done in just a particular way to give satisfactory results. When the experiment is under way, there is a period of nearly four hours when the manometer must be under nearly constant observation, while readings are being recorded. The analysis of the solutions at the end of a run involves titrations with very dilute stand-

ard solutions (0.005 *N* sodium thiosulfate and 0.002 *N* iodine) because the various substances sought are only present to the extent of a few hundredths or, at the most, a few tenths of a milligram in the aliquots taken. Frequent blanks on reagents must be run. Any relaxing of scrupulous care during the whole procedure would lead to the introduction of errors which would entirely vitiate the results.

Here is pictured a type of work which requires unflagging patience and unwavering attention to detail, but which never becomes quite monotonous because of the variation from run to run and because new difficulties are always slipping in which must be conquered—work which requires considerable ingenuity in the interpretation of the results, and which carries with it the satisfaction of being really worth doing.

THE QUALIFICATIONS AND TRAINING OF THE RESEARCH CHEMIST

Education: It is almost necessary to have a Ph.D. in order to qualify for a position as research chemist. Of the thirteen chemists on our staff, eleven have doctor's degrees. There are two women with M.S. degrees; incidentally, there are four women with Ph.D. degrees. Some of our chemists have majored in biochemistry, others in organic and physical chemistry. A good reading knowledge of French and German is essential. Some proficiency in mathematics is highly desirable as in any chemical research. It is also essential to be able to make a thorough review of the literature on a given subject.

Personal Qualities: Resourcefulness, great patience, imagination, and the ability to think logically, are necessary in the research chemist. Just as the teacher must have unfailing patience with people, the research worker must have endless patience with things. Frequently, the man who makes an excellent teacher is bored by the details of laboratory work. Research always involves a great deal of detail work which may, in itself, be monotonous.

The movies, stories with a pseudo-scientific flavor, and even Vallery-Radot's excellent biography of Pasteur, give the impression that research is all very thrilling and exciting. It may have been easy for the early chemists to make important discoveries with little labor, but that is not true now. Research has its charm and its soul-satisfying qualities, in which it is surpassed by nothing else. But most discoveries are preceded by an immense amount of plodding labor. Anyone who is bored by routine should not think of going into research. But the mere ability to plod along patiently is not enough; there must be the imagination which glimpses the distant goal. And when the way to the goal is blocked in one direction, there must be the ingenuity which finds new ways through and around the difficulty. And so the research worker must have two almost contradictory qualities: a lively imagination and the ability to plod. The importance of developing the imagination, if one is to go into research, needs stress. Children always seem to have plenty of the faculty, but adults too often have lost it somewhere in the process of growing up. And imagination is a very important force in the growth of science.

The importance of being able to think logically is obvious. Research is always compelled to involve so much long distance reasoning: a small amount of data is obtained experimentally, and from that, many deductions are drawn. This becomes necessary because so many points are not amenable to direct experimentation; in science, we come at so much knowledge indirectly, by reasoning. Hence, it is important for the young would-be chemist to develop his ability to carry out a train of reasoning that is unshakable in its logic.

An IMPROVED HYDROGEN SULFIDE GENERATOR

C. W. BENNETT

Western Illinois State Teacher's College, Macomb, Illinois

A STEADY, dependable source of hydrogen sulfide under pressure is a prime requisite for most systems of qualitative analysis. The installation to be described represents the sum of improvements made over a period of years on an apparatus designed by J. H. Ransom of Millikin University.[1]

[1] RANSOM, J. H., "An efficient hydrogen sulfide generator," *Trans. Illinois State Acad. of Sci.*, **24**, 310–1 (1931).

The principle is the same as that of the Kipp generator. Three large bottles take the place of the three chambers of the Kipp outfit. The gas is generated by means of the action of undiluted commercial hydrochloric acid on lumps of ferrous sulfide which are placed over a two-inch layer of broken pottery chips in the bottom of a 4-1. aspirator bottle. The acid is kept in a reservoir made from another 4-1. aspirator bottle

fastened by means of clamps to a foot-length of $^1/_2$" gas-pipe which is free to move up and down on a large ring-stand. The reservoir is connected by about two feet of rubber tubing to a 2-1. bottle so that, when the latter is full of acid and the reservoir is slightly higher, the weight of the acid will cause it to flow into the bottle containing the ferrous sulfide lumps. The height of the reservoir is adjusted so that when a very small amount of gas is liberated, its pressure will be sufficient to force the acid back into the reservoir. Thus the

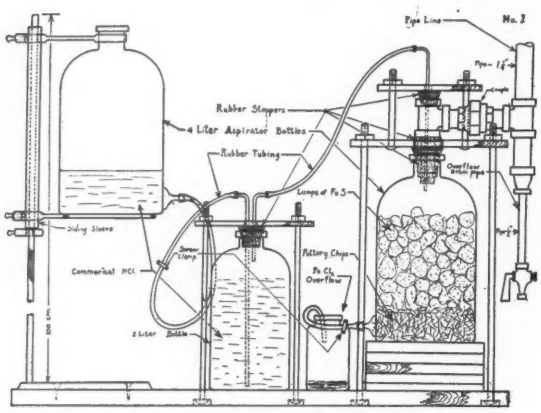


FIGURE 1

pressure can be kept practically constant. For general use the outlet on the reservoir bottle should be just above the intake on the generator bottle. (See Figure 1.)

The unique feature of Ransom's set-up is the use of bolts to hold the stoppers in place against the gas pressure. The present writer mounts the whole apparatus on a board 24" × 12" × 2". Bolts coming up from this base go through oak pieces over the stoppers which hold the latter firmly in place. The two larger strips are 11" × 4" × 1" while the small one over the generator bottle is 6" × 4" × 1". The main improvement, however, is the use of pipe fittings in the gas outlet. This prevents blow-outs and stoppages which are frequent when rubber and glass tubes are used. The detailed drawing (Figure 2) shows the design of this part. A $^1/_2$" tee[2] rests on an inverted rubber stopper through which is forced a nipple about 4" long screwed into the tee. Below the stopper the nipple goes through the strip used to bolt the stopper in and then through the generator-bottle stopper where it is tightly held by a bushing.

[2] Pipe fittings are always sized according to the inside diameter of the pipe to be used. The outside of the prescribed tee will be perhaps more than an inch in diameter since its opening must be large enough to hold a pipe the inside diameter of which is $^1/_2$". These fittings may be picked up from a junk dealer, the local plumber, or from one of the mail order houses.

A horizontal $^1/_2$" nipple about 4" long screws into the middle opening of the tee and is connected by a union to the permanent gas line so that the generator may be removed at will.

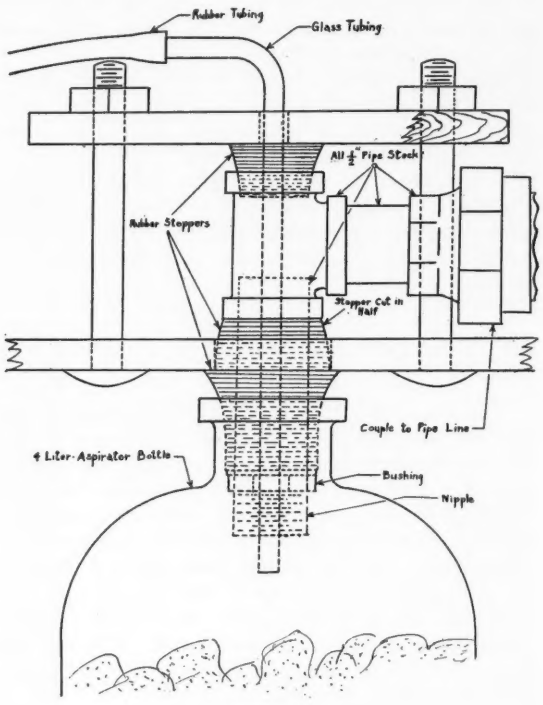


FIGURE 2

The permanent service line consists of another nipple about 4" long screwed into a reducing tee which holds a $1^1/_4$" pipe in order to prevent clogging and to allow condensation of moisture. At the bottom is a valve for

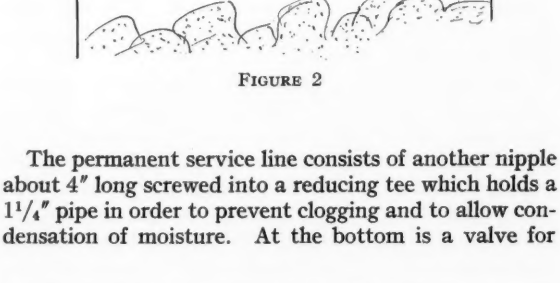

Pipe is Embedded in Wall
All ½" Pipe Stock
Bushing to Reduce to ⅜" Jet Size
Open
Closed
To Generator
Regular ⅜" Gas Stove Jet With end Cap Removed

FIGURE 3.—TOP VIEW

draining, although this is rarely necessary. The upper part then runs into the elbow connected to the horizontal line imbedded in the back wall of the hoods. (See

Figure 3.) This line consists of a succession of $^3/_4$" nipples and tees reduced to $^1/_8$" for the outlets which consist of regular gas-stove cocks bought from a chemical supply house. While they do corrode after some time, these are so convenient that they more than make up for the necessity of occasional replacement. The adjuster on the cock should be screwed off and discarded; thus a reducing outlet is left which is suitable for a variety of sizes of rubber tubing.

The class must be cautioned always to use the pressure system. The valve must never be turned on unless the flask containing the material to be saturated is fitted with a one-hole rubber stopper carrying a glass tube and is connected to the opening by a length of rubber tubing. If any of the valves are left open in the atmosphere the pressure is lost, with the result that acid will flow into the generator bottle. As soon as the valve is closed the acid makes so much gas that the bottles are insufficient to hold it and it will bubble out through the acid.

The outfit described will be adequate for a class of twenty-five for a whole term with very little attention unless the $FeCl_2$ drain becomes stopped up. This can be prevented by the use of ferrous sulfide sticks or fairly large lumps and by avoiding the use of powdered material.

A RAPID METHOD FOR DRYING SYNTHETIC PRODUCTS WHICH ARE SOLIDS

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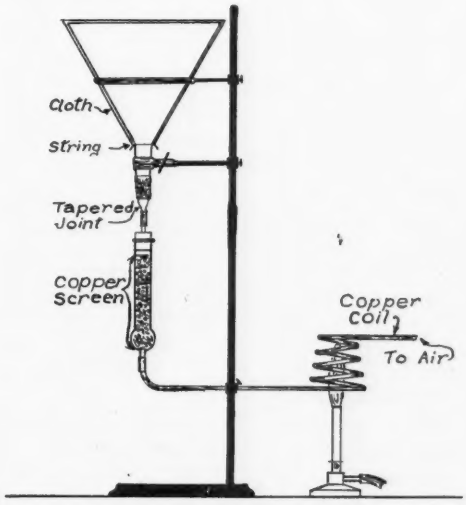
IN THE organic laboratory one is often confronted with the problem of drying either crystalline or amorphous solids which are the products of many types of synthesis. The use of either porous plates or an oven are the usual methods resorted to for this purpose. However, the first method is somewhat slow and many times the nature of the product does not permit the use of heat. Therefore, the following apparatus was devised and used with success to dry both crystalline substances and amorphous powders.

The apparatus consists of an eight-inch funnel over which is tightly stretched a closely woven cotton cloth which is held in place by tying with a string at the point where the flanged part of the funnel joins the stem. The funnel is held upright by means of a ring stand and an eight-inch Bunsen clamp. A calcium chloride tube is attached to the stem of the funnel by means of a tapered glass tube. At each end of the calcium chloride tube is placed a small square of copper screen and a cotton plug. The calcium chloride tube may contain Dehydrite or anhydrous calcium chloride as a drying agent. The other end of the calcium chloride tube is attached to one end of a copper coil which may or may not be heated with a Bunsen burner flame. The copper coil is then connected with an air jet. The adjoining figure will serve to show the arrangement of the apparatus.

Experimentation has shown that from seventy-five to one hundred grams of the wet material can readily be spread over the cloth surface. Air is then passed through the apparatus. The time required for drying the material varies from thirty to forty-five minutes, depending on the nature and amount of the material used. The use of warm air shortens the drying time considerably.



A CONVENIENT METHOD *of* MOUNTING CONDUCTIVITY *and* POTENTIOMETER SETUPS

PHILIP E. HATFIELD AND A. STRICKLER

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WE ARE interested, in our laboratory, in the development of equipment that is convenient, compact, and portable because, like most small laboratories, it is often difficult to find sufficient space in which to make semipermanent setups. We are also interested in the adaptation of amateur radio equipment and methods to physical chemical technic. In this connection we recently (*1*) presented a portable thermostat with a modified electron tube control. This paper describes a method of mounting conductivity and electromotive force equipment and gives some new suggestions regarding connections and endpoint control.

The equipment is mounted in a so-called "standard relay rack." This is not, however, the all-steel rack used in the communications industry but is an inexpensive one constructed of wood. The rack is 60 inches high and 19 inches wide, made of 1-inch pine. The panels are 19 inches by 8½ inches, and are made of ¼-inch plywood. The rack is mounted on a wood platform which is in turn supported by rubber casters. The entire unit is painted black (Figures 1–4).

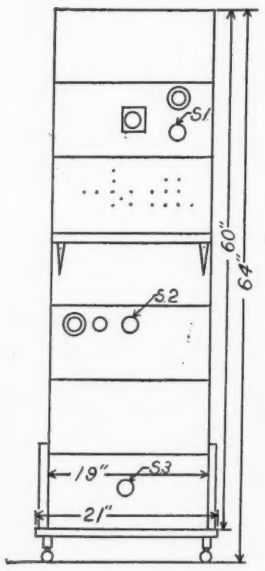

FIGURE 1

The bottom panel unit (*A*) contains the power supplies for the oscillator and the balance indicator. The third panel unit (*C*) contains the oscillator and its amplifier. The fifth panel unit (*E*) carries the terminal board for the conductivity bridge and the E.M.F. setup. The sixth panel unit (*F*) contains the balance indicator. The seventh panel unit (*G*) carries the operating instructions. The second and fourth panels (*B* and *D*) have been left empty to accommodate additional equipment which can be added later. A shelf 19 inches by 12 inches is mounted on the front of the rack, 33 inches from the bottom, to hold the slide wire, resistance box, and key.

The oscillator is patterned after that of Saylor and Debruyne (*2*), and contains a stage of amplification to increase its output and at the same time isolate it from the bridge. However, certain changes have been made. A pair of type 27 tubes have been substituted for the type 71a's so that alternating current can be used on the filaments. A superhet intermediate frequency transformer is used for the oscillator coil. In addition, the difficulty of matching the oscillator to a student-type slide wire has been overcome by using as an output transformer one which was removed from a dynamic speaker. This transformer is designed to match the plate of a type 45 tube to a 30-ohm voice coil. The oscillator and its amplifier are shielded by copper cans. A grounding system patterned after that of Jones and Josephs (*3*) is used on the oscillator. A 100,000-ohm potentiometer is connected across the output of the oscillator and the sliding arm connected to ground. The output of the oscillator is fed to the terminal board through shielded, grounded cable.

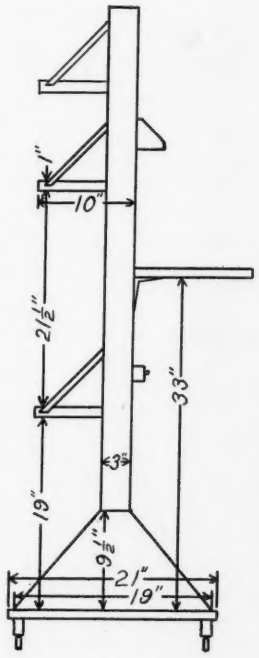

FIGURE 2

The terminal board is arranged so that the slide wire, resistance box, and key may be placed on the shelf which is located just below it. These are connected into the circuit with short wire jumpers. This allows these units to be easily removed for storage, or for use in another place. The terminal board panel

also carries a telephone jack into which can be plugged either a pair of head-phones or a patch cord from the visual balance indicator to indicate bridge balance.

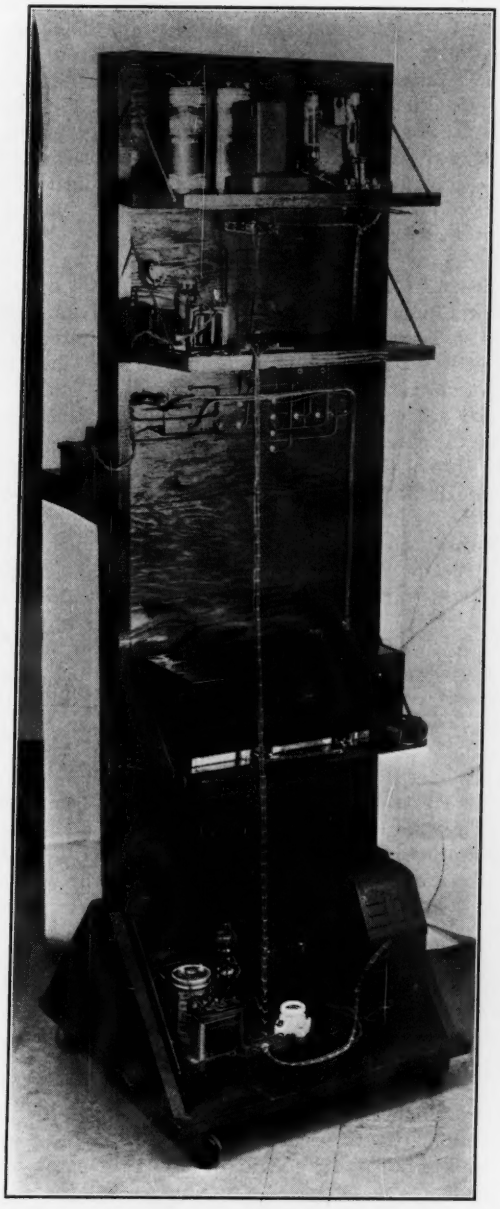

FIGURE 3
Photograph by R. A. Neville

A Leeds and Northrup Student Slide Wire is used in the setup, but any similar type can be used.

The balance indicator is a visual one described by Garman (*4*) and uses a type 75 tube with a meter in the plate circuit which shows a maximum reading when the balance point of the bridge has been reached. A pointer type galvanometer with a shunt is used for the meter. A patch cord is connected to the input of the balance indicator so that it can be plugged into the telephone jack on the terminal board.

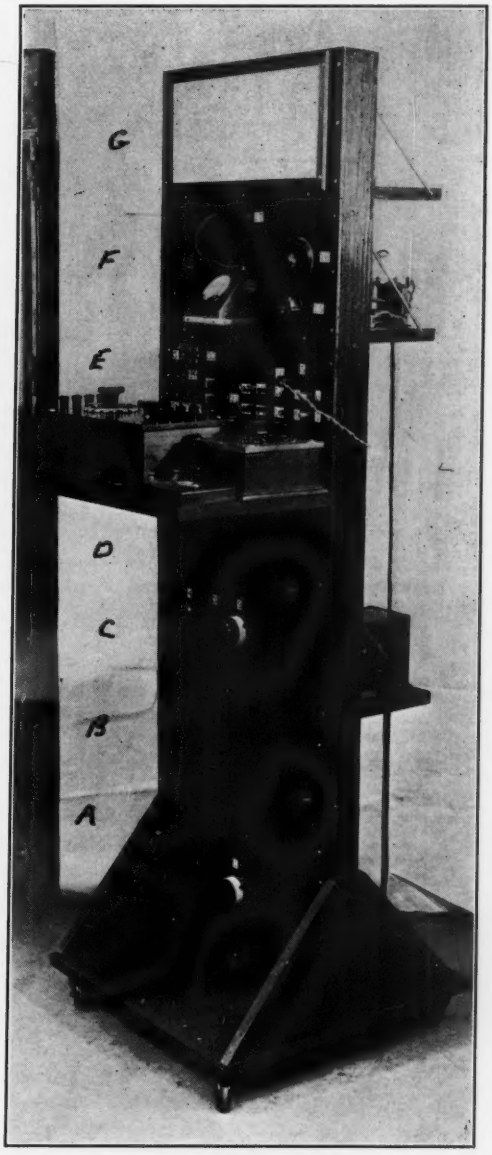

FIGURE 4
Photograph by R. A. Neville

In connection with visual balance indicators some work was done with the type 6E5 "Magic Eye" tube in an effort to use it for this purpose. The fact that the shadow on the fluorescent screen of this tube gives one a practically inertialess pointer gives this tube an

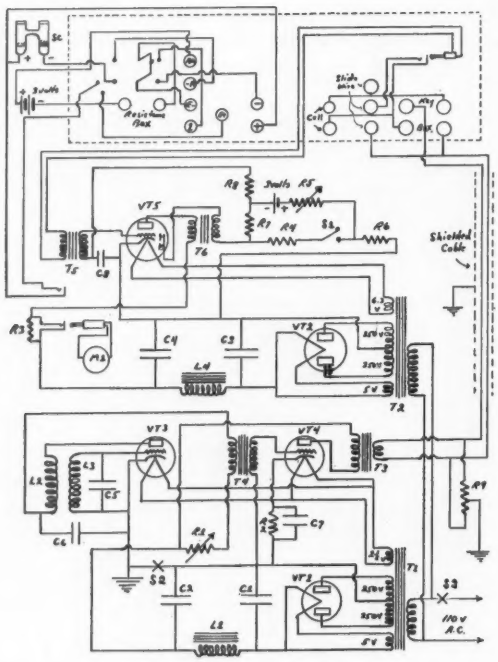

FIGURE 5.—KEY TO WIRING DIAGRAM

T1—Power transformer.
T2—Power transformer.
T3—Output transformer designed to match a type 45 tube to a 30-ohm voice coil.
T4—Audio transformer.
T5—Audio transformer.
T6—Audio transformer.
C1, C2, C3, C4—8 MFD. 400-volt filter condensers.
C5—0.002 MFD. mica condenser.
C6—0.006 MFD. mica condenser.
C7—1 MFD. 200-volt condenser.
C8—0.02 MFD. 200-volt condenser.
R1—50,000-ohm 10-watt variable resistor.
R2—2000-ohm 2-watt resistor.
R3—7-ohm shunt (a section of the resistance strip of a rheostat).
R4—10,000 ohms 2-watt resistor.
R5—75,000-ohm variable resistor.
R6—1 megohm 2-watt resistor.
R7—10,000 ohm 2-watt resistor.
R8—1 megohm 2-watt resistor.
R9—100,000 ohm 10-watt variable resistor.
L1, L4—30 henry 50 milliampere filter chokes.
L2, L3—Primary and secondary of a superhet IF transformer.
M1—Weston model 375 galvanometer.
VT1, VT2—Type 280 tubes.
VT3, VT4—Type 27 or type 56 tubes.
VT5—Type 75 tube.
SC—Weston normal cell.
S1, S2, and S3—Single-pole single-throw snap switches.

advantage over meters. However, lack of equipment caused abandonment of this type of balance indicator before one which was sensitive enough could be designed.

The two power supplies for these units are mounted in the lower part of the rack. They are composed of broadcast receiver parts and each supplies a potential of 250 volts direct current, as well as the alternating current voltages necessary to light the tube filaments.

In order to set the potentiometer used to ground the setup, a known resistance is substituted for the conductivity cell and the resistance box is set at the value of the known resistance. The grounding potentiometer is then adjusted until a balance is secured in the bridge with the slide wire set at its midpoint. The conductivity bridge is used in the conventional manner except that the visual indicator is employed to show the balance point. The balance point has been reached when the galvanometer mounted on the balance indicator panel reads maximum. This galvanometer has also been arranged so that it can be unplugged from the conductivity circuit and plugged into the E.M.F. measuring circuit. The two jacks for these circuits are mounted side by side on the panel, just above the galvanometer.

The use of the visual method is a distinct advantage in a small laboratory in which a number of people are working, as it is very difficult to find a balance point with the head-phones in anything but a quiet room.

The entire conductivity setup can be rolled alongside the water bath or table containing the conductivity cell, and when measurements have been completed it can be rolled away and stored in a corner without disrupting the setup. This is a distinct advantage over desk setups which must be dismantled when the desk is to be used for other purposes.

In addition to conductivity measurements the setup can also be used for E.M.F. measurements. A Weston Cell and two dry cells are mounted on the top shelf. A set of terminals, a push button, and a double-pole double-throw switch are mounted on the terminal board so that the same Leeds and Northrup Student Slide Wire can be used by changing the wire jumpers over from the set of terminals used in making conductivity measurements to the terminals which are hooked into the E.M.F. measurement circuit. The meter plug is placed in the other jack, and the meter is thus hooked into the E.M.F. circuit. The wiring diagram of the terminal board is included in the hookup of the entire setup (Figure 5). Some modification of this would probably be necessary if another type of potentiometer was used.

Each terminal and control on the entire setup bears a number. A framed instruction sheet on the top panel guides the student in connecting the equipment by reference to these numbers.

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The HISTORY *of* CHEMISTRY *and* ITS PLACE *in the* TEACHING *of* HIGH-SCHOOL CHEMISTRY*

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FOR many years I have been interested in the story of chemistry. This interest began with the lectures of Charles Baskerville, one-time President of the American Chemical Society. We had no formal course at the college either in the history of chemistry or in the history of science. His talks served as my introduction to elementary chemistry. Baskerville would intersperse his chemistry lectures with vivid thumbnail sketches of the lives of the pioneers of chemistry and with numerous anecdotes connected with their achievements. These stories fired my imagination, and I began to do my own reading in this new field. Today, twenty years later, I feel like that Englishman who, accidentally meeting Mark Twain in a train, remarked, "You know, Mr. Clemens, I would give ten pounds not to have read your Huckleberry Finn." And when Mark Twain looked up, bewildered by what appeared to be a gratuitous insult, the Englishman smiled and quickly added, "so that I could have again the great pleasure of reading it for the first time." For me the history of chemistry still remains a most absorbing avocation.

It is generally agreed that the immense store of scientific knowledge gathered and set to work through the centuries by the travail of great thinkers and manipulators stands today as the greatest conquest of the human mind. If used generously and wisely this body of knowledge could usher in a renascence of the entire world within a brief span of years. The titanic struggle to bring us to this state of enlightenment regarding the universe represents the most important intellectual battle that man has fought and won.

Yet this epic is unknown to most of our pupils and even to many of our science teachers. Why? Because as many eminent and farsighted men such as Wilhelm Ostwald have repeatedly pointed out there is "a defect in the present scientific education of our youth. It is the absence of the historical sense and the complete want of knowledge of the great researches upon which the edifice of science rests." Today, of course, general scientific information is more universally disseminated than ever before, and even high-school children are taught elementary principles which were not considered necessary for so-called cultured people a century ago. Lecky, for example, in his "Democracy and Liberty" remarked that the whole field of modern scientific discovery seemed out of the range of even such a scholar and statesman as Mr. Gladstone, and tells how, when Michael Faraday was endeavoring to explain to England's Prime Minister his new discovery of the production of electricity by mechanical movement, Gladstone's only comment was, "But after all, of what use is it?" And you may recall Faraday's memorable reply, "Why, sir, there is every probability that you will soon be able to tax it."

Yet so far as the history of scientific advance is concerned our pupils are still profoundly ignorant. From the very beginning and through the first three-quarters of the nineteenth century chemistry teaching in the United States was superficial, informational, and practical. Many of the textbooks employed were of the catechism type, and seldom were references made to the development of the science. Even the names of Priestley and Lavoisier were denied a place in these early chemistry texts. The reasons for this dearth of biographical and historical material are not difficult to find. America was a new country. Rich natural resources were here to be tapped. Vast prairies and fertile fields smiled graciously on the pioneers. Immense forests stood ready to be stripped. Mountains of gold waited to be dug. Enormous deposits of coal and bursting reservoirs of petroleum needed but to be struck to give forth a steady flood of power. With a virgin country waiting to be exploited, the mind, the hand, and the energy of our people were occupied with this highly practical problem of subduing a country and gaining dominion over it. Facts and methods were wanted. In such an atmosphere as this the pragmatic philosophy of William James was born. There was neither time nor thought for the purely cultural elements of chemistry when every value of science was measured in terms of service and function. These forces reflecting an industrial revolution made it very difficult for educators to emphasize anything but the immediate, utilitarian values in the teaching of such a practical subject as chemistry. Facts, facts, and more hard facts was the cry which quickly drowned any voice that might have protested that this philosophy was alien to the true spirit of science teaching.

A reaction against this stifling educational practice finally set in, however, and mental discipline then became the commonly accepted aim of the teaching of the

* Presented before the Central Ohio Teachers' Association at the Engineers Club, Dayton, Ohio, November 5, 1937.

sciences. Schoolmasters were now of the opinion that what was needed was a kind of training that would give the child mental powers, general principles, and, above all, a method or process for the solution of many different kinds of problems and for the doing of numerous types of work. With this changed outlook came the introduction of a new tool, individual laboratory work, by means of which an attempt was made to develop a kind of mental resourcefulness and dexterity for general use. The laboratory work, unfortunately, did not follow the experiments of the founders of chemistry, nor did it throw any real light upon their methods and technics. The literature of the classic researches was still left to gather dust on the shelves of science historians and antiquarians. The spirit of true research was absent and the smell of the laboratory was not that of the workshops of the immortals of scientific advance, but rather the odor of the apothecary shop and the industrial chemical plant. Laboratory methods were formalized and standardized. The laboratory work became essentially a means of memorizing subject matter. Textbooks followed the strictly logical cookbook system of organization. The colleges dominated the high schools, and their narrowly conceived entrance requirements were largely responsible for the mental straightjackets in which the high schools were confined.

This dichotomy of science study and a real liberal education continued to overshadow if not completely eclipse the more worthwhile purposes and ideals of science teaching. Sir Richard Gregory in his "Discovery" well expressed this division as follows. "Scientific and humanistic studies," he wrote, "were indeed supposed to be antipathetic, and to represent opposing qualities: so that it became common to associate science with all that is cold and mechanistic, and to believe that the development of the more spiritual parts of man's nature belongs to other departments of intellectual activity."

The result of this sharp dichotomy has been disastrous. America, to be sure, has produced a number of first-rate scientists including eleven Nobel Prize winners. But the complaint has often been heard that the great army of our youths who have marched through our school science laboratories appear to be little touched by the influence of the scientific method of thinking and the high ideals of pure scientific research. Charles Beard recently expressed what is perhaps the general opinion of educators. "Our various scientific courses," he said, "rarely produce either of the main results to be expected from them. They neither engender in the student a discriminating and exacting tendency of mind—that combination of open-mindedness and caution which should be the finest fruit of successful scientific training—nor do they foster such a lively understanding of the workings of nature that the fascination of discovery of ever new wonders will endure through life and mitigate sorrow, boredom and disappointment."

These fundamental indictments are happily being taken seriously by progressive science educators. During the last decade or two a re-evaluation of objectives and a re-examination of methodology in the teaching of secondary-school chemistry have been made. The functions of high-school chemistry teaching are, of course, many. Among them may be included the accumulation of worthwhile knowledge, the training of right habits of work, the development of both mental power and of a well-balanced mind, character building, and its recreational value. These objectives are being rearranged with respect to their relative importance in the light of the fact that while very few of our pupils can ever hope to become professional scientists, all must engage in a multitude of life activities in a rapidly changing world. The new philosophy is, therefore, definitely gravitating toward greater emphasis upon those elements in the course of study which will help our pupils to become more socially efficient, more critical of social changes, more easily adjustable to sudden dislocations, more keenly aware of the real values of life, and possessed of a wider and deeper esthetic appreciation which may lead to a fuller and more useful life.

Now how far have reorganized curriculums and teaching procedures caught up with this changing philosophy? Let us look at some facts. The present New York State Regents Syllabus in chemistry includes many excellent standards and goals. It declares, for instance, that "Unquestionably, general human progress has been delayed by the lack of those mental habits (such as intellectual honesty and fearless inspection of data and conclusions) which, as used by scientists, have brought about the rapid development of science." It goes on to say that "there are two chief points of view in teaching a science in the high school. One aims at preparing the pupil as a novitiate for entrance into the profession itself. The other considers it legitimate to take from the subject matter whatever will enrich the individual life of the pupil and only such things. In the elementary course it is the second of these views which should mainly determine the teacher's attitude." In its suggestions for teaching the scientific attitude it lists several scientific habits such as careful experimentation, the willingness to accept criticism, the refusal to keep discoveries secret, and so forth. And in a final summary it emphasizes the point that "The scientist has conceived a rather new idea—that of morality in the world of ideas."

Very recently the Committee of Chemical Education of the American Chemical Society recommended "An Outline of Essentials for a Year of High-School Chemistry." The committee went on record as follows. "In the high school the view point should be informational, broadening and cultural as contrasted with the technical, professional and specialization attitude which is unavoidable in the college." Among the aims of high-school chemistry, it lists: (1) To train the student in keen observation, exact reasoning and in the scientific attitude of mind; (2) to show the service of chemistry to the country; (3) to help pupils find

themselves, *i. e.*, to discover whether or not they have an aptitude for further study as chemists; and (4) to encourage pupils to use reference books and periodicals. Many other syllabi used throughout the United States doubtless have identical aims and recommend biographical material and the study of individual scientific researches.

The failure of this alleged humanistic approach, however, lies in the fact that it depends upon rather broad generalizations, and fails to include in curriculums definite topics to be taught. For example, the New York State Syllabus above quoted recommends at least one important research, and outlines two researches in the history of chemistry, namely (1) oxidation of metals and (2) discovery of argon. It indicates but two references, in its syllabi, of historical material, namely, that the introductory work should conform to the historical development of the subject, and references should be made to the contributions of Priestley and Lavoisier. The syllabus of the American Chemical Society's committee lists also only two, namely (1) a brief history of the development of chemistry, and (2) a history of the Periodic System. These examples are representative of many other syllabi.

And what of our most up-to-date textbooks which should have caught up with the new philosophy? J. O. Frank, Professor of Science Education at The Wisconsin State Teachers College made a study in 1935 of twenty textbooks of high-school chemistry. He found that while the amount of space given over to some brief account of the development of modern chemistry from the early days of alchemy has doubled since 1931, not a single textbook gave a clear connected account. He reported historical items usually scattered through the texts such as references to the discovery of radium, oxygen, argon, and helium, and Mendeléeff's Periodic Table. On the biographical side there is a similar sorrowful lack of uniformity. Of the three hundred thirty-six names occurring in the twenty textbooks, only *four* names were mentioned by all the authors. Half of the three hundred thirty-six names were mentioned in only *one* book, and two hundred fifty-eight occurred five times or less. Frank's conclusion reads in part as follows. "In spite of the widespread belief among chemistry teachers in the value of historical material as an aid in developing interest in chemistry and an understanding of its present status, there is no agreement among the textbook authors as to what historical material should be given nor how it should be presented. . . . . There is a general confidence in pictures and names and only a feeble effort to outline the history of chemistry."

Now I realize that wideawake progressive teachers introduce historical and other cultural material, if not formally then at least incidentally, for the value of the historical method of approach is universally recognized. Yet the great mass of our chemistry teachers follow the syllabus and the textbook slavishly and have neither the urge nor the will to search out historical references and classic researches in an effort to vitalize their lessons. This material must be before the teacher in both his syllabus and textbook if it is to be taught effectively and wholeheartedly. Neither am I convinced, as some have suggested, that the study of chemistry can be made simply a study of the great figures of the science. The American biographer, Gamaliel Bradford, writing in 1931 on "Biography's Place in a Modern Scheme of Education," expressed his conviction that "For us human beings all that makes the value of knowledge is simply the human being. It is biography that binds together all the varied branches of thought and life. Plato and Kant make philosophy, and they are human. Copernicus, Newton, and Darwin make science, and they are human. Biography has, more than any other study, the immense advantage of affording a natural link between the otherwise scattering and mutually repellant divergencies of developing knowledge." With this thought I cannot agree. Chemistry cannot, on the high-school level, be made solely the essence of a number of important biographies and researches. The objectives of chemistry are too broad and the methodologies too varied to treat it merely as the biographies of its leaders writ large. I have no polyphemic eye to the superiority of the historical-biographical approach to the exclusion of all other methods. And neither do I recommend a course in the history of chemistry in the high schools.

But I do firmly believe that within the framework of a slightly modified course containing generally accepted minimum essentials more historical material should be introduced. I believe that the history of chemistry should be made the leading thread in a beginning course. Facts are to be subordinated to intellectual appeals and to those other humanistic values which lie on the periphery of a course of study whose core continues to remain substantial enough to give it lasting strength. "Deep appreciations should go hand in hand with fundamental understanding." We must not fail to maintain a balance between the necessary factual material and the stimulating elements relating to the lives and accomplishments of the men and women who have given us a chemistry which can help the pupil to a clearer understanding of life and to a more healthful and complete one.

I feel sure that you agree with me that some of the history of chemistry should be taught in secondary-school chemistry if we are not to slip back into the morass of a purely factual chemistry. The field of chemistry is a vast one, however, and we must, therefore, give a great deal of thought to what we are to include. In selecting the material which I propose to add in the reconstruction of the chemistry curriculum I have been guided by two criteria. First, I have asked myself the question, "Will this material fit into the story that leads to a quick unfoldment of the birth, rise, and development of the science so that the pupil gets the feeling that chemistry has not grown spontaneously to its present state, but that it is a slowly evolving product of human mentality?" Second, it must give an affirmative answer to the question, "Does it clearly illus-

trate the method of scientific research as well as the spirit of the men at work? Does it portray, as Venable believed, 'first the groping after causes, the struggle to frame laws, intellectual revolutions, bitter controversial conflicts, and the crash and wreck of fallen philosophies.' "

The following is a list of what I consider the minimum essentials of the humanizing elements to be included in an elementary course in chemistry.

(1) A very brief account of *the beginnings of chemistry* in the primitive and technical arts of the ancient Chinese, Babylonians, Egyptians, and Hindus which included a body of empirical knowledge dealing with the smelting of ores, dyeing operations, the making of ceramics, fermentation processes, and embalming.

(2) A brief mention of the widespread and prolonged *reign of alchemy*, parent of modern chemistry, and of the two chief goals of alchemy: (*a*) transmutation, or the making of gold from cheaper metals, and (*b*) the search for the elixir of life which would ward off old age and illness.

(3) The development of the concept of a *chemical element* by Robert Boyle after the hoary acceptance of the four elements of Aristotle, and the numerous later attempts to find the elementary substances from which the world was built.

(4) The *discovery of oxygen* by Priestley in 1774.

(5) The gradual solution of the riddle of *fire* by tracing its various phases from the *spirit* of the ancients, the fire principle of Aristotle, the phlogiston of Becher, and the final experimental proof of its true nature by Lavoisier.

(6) Lavoisier's emphasis upon the use of the balance in chemical experimentation, the Law of the Conservation of Matter, and *the birth of modern chemistry.*

(7) The solution of the nature of *water.* To be traced from the *water* principle of Aristotle, the discovery of hydrogen by Cavendish, and the final proof of the compound nature of water by the same Englishman who sparked a mixture of air and hydrogen. Lavoisier's experimental confirmation to be described.

(8) The solution of the nature of the *air*, another of the four principles of the ancients. Review the discovery of oxygen by Priestley, of nitrogen by Rutherford, of carbon dioxide by Black, of helium by Lockyer, and of argon and the other inert gases of the atmosphere by Ramsay and Rayleigh.

(9) The concept of the *discontinuity of matter.* The ancient's ideas of atoms as compared with the atomic theory of Dalton. How Dalton arrived at this theory. The development of the concept of molecule by Avogadro, Cannizzaro's aid, and the final acceptance of Avogadro's Law.

(10) Chemistry becomes *a quantitative science* with the introduction of Dalton's atomic weights, the establishment of the Law of Definite Proportions by Proust, and the discovery of the Law of Multiple Proportions by Dalton.

(11) The *development of chemical symbols* from those used by the ancients, the alchemists, and by Dalton to the introduction of modern symbols by Berzelius in 1814. The pioneer work of Lavoisier in giving shape to the grammar and nomenclature of modern chemistry.

(12) The *Electron Theory.* This story to include the discovery of (*a*) cathode rays by Crookes, (*b*) X-rays by Roentgen, (*c*) radium by the Curies, (*d*) the electron by J. J. Thomson (Millikan's weighing of the electron), (*e*) the proton by the late Ernest Rutherford, (*f*) the Law of Atomic Numbers by Moseley (to be compared with Mendeléeff's Periodic Table), (*g*) the neutron by Chadwick (mention Harkin's prediction of the discovery of this entity), and (*h*) the positron by Carl Anderson. The history of the Lewis-Langmuir chemical atom, the Bohr atom, and the wave theory of the atom as introduced by De Broglie should also be briefly included. Wilson's invention of the cloud-chamber apparatus, Aston's work with the mass-spectrograph and his discovery of isotopes also belong here. Lawrence's cyclotron, the actual transmutation of elements, and Urey's discovery of heavy hydrogen and heavy water should likewise be included.

(13) The origin and development of the *Theory of Ionization* by Arrhenius, and its relationship to the Electron Theory of Matter.

(14) The history of *a few non-metals:* (*a*) the discovery of chlorine by Scheele and of its bleaching action by Berthollet. Illustrate science as a two-edged sword—its use in war and in peace. (*b*) The discovery of phosphorus as a contribution of the alchemists. (*c*) The development of the Frasch process of extracting sulfur and its effects on the Italian and American sulfur industries.

(15) The *rise of electro-chemistry* from the invention of the electric battery and the isolation of sodium and potassium by Davy. The spectroscope of Bunsen and Kirchhof and its use in chemistry.

(16) The rôle of *steel, aluminum, and petroleum* in the economic development and life of modern America. The history of the introduction of the Bessemer process for making steel, the Hall process for extracting aluminum, and Drake's first successful oil venture should be included, for the teaching of the social consequences of the advance of science is part of the business of teachers of science.

(17) The chemist is revolutionizing industry. The rise of *synthetic inorganic chemistry* as illustrated by the Haber process for the Fixation of Nitrogen.

(18) Chemistry creates new industries. The rise of *synthetic organic chemistry* with references to (*a*) Woehler's synthesis of urea (mention the old distinction between organic and inorganic chemistry); (*b*) Baeyer's synthesis of indigo which marked the death knell of the natural indigo industry; (*c*) the synthesis of methanol; (*d*) the introduction of rayon and Bakelite; (*e*) the growth of synthetic gasoline by the Bergius process; and (*f*) the possibilities of synthetic rubber cheap enough to compete with natural rubber. The economic effects of this revolution upon world events.

(19) Our *newer knowledge of nutrition*, vitamins,

hormones, and anesthetics. Their effect on the health and lifespan of man. Their social implications. References should be made to the work of E. V. McCollum, J. J. Abel, F. G. Banting, Humphrey Davy, Horace Wells, William Morton, Charles Jackson, and Crawford Long.

(20) The rôle of *chemistry in agriculture.* Liebig's pioneer work in the study of fertilizers.

How is this material to be included? Not as a series of disconnected narratives to be thrown in to meet the requirements of curriculum builders. Not as a brief history of the obituary type to be administered as a prescription for the good of the soul. But rather by weaving through the web of the course of study the threads of chemical history which show men of research in action and men of science as figures in a great pageant of discovery. The story of chemistry should be placed in its proper setting of the still greater story of man's achievements.

Two methods should be employed in presenting this material. One is the biographical. "The great object, in trying to understand history, political, religious, literary or scientific, is to get behind the men and to grasp their ideas," wrote Lord Acton. It is the method of some of our best teachers like the late Edgar F. Smith and Charles Baskerville. Youth is a period of hero-worship, and there is high adventure in the life and struggle of many of the great figures of chemistry. From the lives of the chemists of the past and present can be brought out vividly and effectively many of the qualities of the true men of research. As a character builder it has few methods to equal it. I offer a few examples from the list quoted above.

(1) The scientist's *duty to humanity* can well be portrayed by (*a*) Davy's refusal to take out a patent on his miner's lamp, saying, "No, my good friend, I never thought of such a thing; my sole object was to serve the cause of humanity, and if I have succeeded I am amply rewarded in the gratifying reflection of having done so;" (*b*) Roentgen's remark about the X-ray, "The discovery belongs not to me, it belongs to the human race;" (*c*) John J. Abel's refusal to fight Takamine's claim to adrenalin although it could have made him very rich.

(2) To depict the *perseverance, tireless effort, and hard work* of men and women of science one could do no better than to quote from the life of the Curies. "The bitter winter of 1896 came and found that mad couple still laboring in their hangar. Marie was bound to break under this terrific strain. Soon pneumonia made her take to bed, and it was three months before she was strong enough to return to her boiling cauldrons. Pierre, her husband, too, was broken with fatigue at the end of each day's work. Yet the search went on, and Marie confessed that 'it was in that miserable shed that we passed the best and happiest years of our life.'"

(3) To illustrate the *inner satisfaction* which comes to men of science quote Robert Boyle, the 14th son of the Earl of Cork who gave us our first correct concept of a chemical element. "In my laboratory," he wrote, "I find that water of Lethe which causes that I forget everything but the joy of making experiments."

(4) *Physical courage* has been shown by many men of research. The story of the battle to find the cause and cure of pellagra can be told in connection with the study of the vitamins. In 1914, Joseph Goldberger, an immigrant boy, son of a grocer on New York's East Side was assigned the task of fighting a disease which was playing havoc in the South. Slowly he showed how one theory after another had to be abandoned in explaining the cause of pellagra. When the final step in the proof of his own theory had to be taken he did not flinch from taking it. He injected into his own veins the blood of a woman suffering from an acute case of pellagra. The following day he swallowed the intestinal discharge of another victim. Then he and his wife ate the powdered skin rash of still another sufferer of this scourge. For weeks they waited for pellagra to seize hold of them. But it did not attack them. He had definitely proved it to be a vitamin-deficiency disease, lack of vitamin G, due to poverty.

(5) The *imaginative and aesthetic power* of the scientist is well illustrated by the origin of C. T. R. Wilson's invention of the cloud-chamber apparatus for photographing the electron and other elementary particles of matter. While he was vacationing on the cloudy Scottish hilltop of Ben Nevis, he wrote, "Morning after morning I saw the sun rise above a sea of clouds. The beauty of what I saw made me fall in love with clouds, and I made up my mind to make experiments to learn more about them." Then, during his study of cloud formation he hit upon the idea of the apparatus which, because of its indispensability in the study of atomic physics, won him the Nobel Prize. J. W. N. Sullivan expressed the thought that "it is the scientist, not the poet, who is the dweller in dreamland."

(6) For the new *social mindedness* of contemporary men of science read from Harold Urey's speech at the dedication of the new Mellon Institute building last May. "I believe I speak for the vast majority of all scientific men. Our object is not to make jobs and dividends. These are a means to an end, merely incidental. We wish to abolish drudgery, discomfort, and want from the lives of men, and bring them pleasure, comfort, leisure, and beauty. Often we are thwarted, but in the end we will succeed."

The second method of introducing historical material is to bring the pupil in direct contact with the original researches of the pioneer chemists. Chemistry has a rich heritage in its literature which may inspire our young pupils to drink deeper of its contents later on in life. Through many of these classic researches we can often best illustrate the various elements of what is known as the scientific method of dealing with a problem and of the scientific habit of mind which is so precious. "All the men who are now called discoverers," wrote De Morgan, "have been men versed in the minds of their predecessors, and learned in what had been left before them." Reading and studying the actual

words in the memoirs of these pioneers bring us in throbbing contact with their minds.

Again from the list mentioned above we can illustrate the importance of

(*A*) *The gathering of complete and accurate* data in the work of Cavendish, Ramsay, and Rayleigh. Henry Cavendish was the first accurate analyst of the air. By firing air with pure hydrogen which he had discovered, he found air to contain about twenty per cent. oxygen. During these experiments a small quantity of an acid formed. He was not the first to detect this—Priestley, Watt, and Lavoisier had also observed it. Cavendish sought the source of this acid and found it to be the result of the chemical union of the oxygen and nitrogen of the air during the sparking. (This discovery formed the basis of the first commercial fixation of nitrogen.) Now Cavendish determined to change all the nitrogen of the air into nitrous acid by repeated sparking. During these experiments he left records in his notebook of his crowning achievement—the isolation of a gas which it took another hundred years to discover. Rayleigh, in determining the atomic weight of nitrogen obtained from ammonia gas, found it to be lighter than the nitrogen obtained from the air. He called this to the attention of Ramsay who after two years of work found that nitrogen from pure compounds was 0.5 per cent. lighter than the nitrogen extracted from the air. The difference in weight was very small and might have been ignored as due to experimental errors. But after Rayleigh had spent several more months investigating, he was convinced that the presence of some other element in the air was responsible for the difference in his result, and for the greater weight of the sample of nitrogen obtained from air. Dewar then happened to tell Ramsay of the work of Cavendish, while Crookes suggested to Rayleigh a method of extracting nitrogen from the air based on the work of this same pioneer chemist.

Rayleigh and Ramsay re-read Cavendish's memoirs and came across the following entry. "I made an experiment to determine whether the whole or a given portion of the nitrogen of the atmosphere could be reduced to nitrous acid. . . . . Having condensed as much as I could of the nitrogen, I absorbed the oxygen, after which *only a small bubble of air remained unabsorbed, which certainly was not more than* $^1/_{120}$ *of the bulk of nitrogen*, so that if there is any part of the nitrogen of our atmosphere which differs from the rest, we may safely conclude that it is not more than $^1/_{120}$th part of the whole." With this as their clue both Rayleigh and Ramsay continued their experiments on air, and in 1894 announced their discovery of a new element *argon* whose presence was finally detected by means of its spectrum. This was the gas in the air, heavier than pure nitrogen, which Cavendish had found back in the late eighteenth century had refused to combine with oxygen when the air was sparked. Soon after the discovery of argon the other inert gases of the atmosphere were isolated and the final composition of the atmosphere became known for the first time.

(*B*) *Suspended judgment while experiments are being tried to test a provisional theory* may be very well illustrated by Moseley's success in obtaining proof of Rutherford's theory of the structure of the nucleus of the atom. Shortly after von Laue's discovery that crystals of salt split X-rays like light, Ernest Rutherford propounded the theory that the main mass of the atom was concentrated in a tiny nucleus of positive electricity surrounded by enough electrons to make the atom electrically neutral. He ventured the hypothesis that "the charge in the nucleus of every element ought to be proportional to the atomic weight of the element." Being uncertain as to the validity of this guess he decided to have it tested experimentally while he and the rest of the scientists of the world withheld judgment. Rutherford called in one of his brightest research assistants, Henry Moseley, and asked him to work on the problem. He was to study the X-ray spectra of different elements to determine the nature of the electric charge within the center of the atoms. Within six months, by working steadily and often continuously for eighteen hours a day, Moseley examined the X-ray spectra of thirty-eight different chemical elements, and found Rutherford's theory correct. In 1912 at the age of twenty-six he announced his discovery of the Law of Atomic Numbers, and men of science all over the world were now ready to accept Rutherford's theory as the most plausible one.

(*C*) *For the willingness to abandon a theory in the face of new facts*, we might describe the controversy over the accuracy of the Law of Definite Proportions. A fearless inspection by Berthollet of the data on hand led to an open-minded acceptance of the law, which Proust held to be true. Personal likes and dislikes were ruled out when Berthollet realized that Proust was right. Berthollet had believed in an *almost constant* composition of pure chemical compounds. Joseph Louis Proust, then teaching in Spain, repeated the experiments of Berthollet and did many more of his own. He found a number of errors in Berthollet's analyses, and pointed out that the latter had chosen a number of substances such as glass, alloys, and mixtures of liquids which were not true compounds. For eight years this controversy went on, and never did it become anything but a courteous, brilliant, truth-seeking discussion. Finally, when Berthollet saw the error of his position, he graciously withdrew and accepted the conclusion of Proust.

(*D*) *Intellectual Integrity and the courage to state the truth as one finds it*, can be taught in the treatment of Arrhenius and the Theory of Ionization. "I have experimented enough, now I must think," wrote Arrhenius, as he left his laboratory to return to his home in the country to work out the theoretical part of his research. One night he sat up till very late till suddenly from the sublimated speculations of his experiments there crystallized in a flash the answer to the great riddle. "I got the idea in the night of the 17th of May 1883 and I could not sleep that night until I had worked through the whole problem." His conclusions ran counter to the accepted

theories of his day. He knew there would be a great deal of opposition. He could have temporized and compromised. But he would not. As a candidate for the doctor's degree he had to defend his thesis in open debate. At the end of four hours the questioning was over. He was grudgingly awarded his degree. The award, however, was in reality a veiled condemnation of his theory. His dissertation was awarded a fourth class and his defence a third class. His discouragement at this point almost ended his career as a chemist. He continued to meet a great deal of opposition, and when he appealed to the scientific world outside of Sweden, Clausius was not interested, Lodge recognized the value of his theory but would not help him, and Lothar Meyer did not answer him. Finally, Ostwald came to his aid and Arrhenius was recognized.

(*E*) *To bring home the element of the scientist's humility, and his realization of the fact that even our established laws may not be the final truth,* we might quote Scheele's words in his letter to Bergmann, "It is very possible that my opinions are quite erroneous, time will make it clear," or those of Mendeléeff, "When in 1871 I described to the Russian Chemical Society the properties, clearly defined by the Periodic Law, which gallium, scandium, and germanium ought to possess, I never hoped that I should live to mention their discovery to the Chemical Society of Great Britain as a confirmation of the exactitude and the generality of the Periodic Law. Now that I have had the pleasure of doing so, *I unhesitatingly say that although greatly enlarging our vision, even now the Periodic Law needs further improvements* in order that it may become a trustworthy instrument in further discoveries."

To make the program which I have outlined effective several radical changes are necessary.

(1) Courses in the history of chemistry and in the literature of science must be introduced in universities and teacher-training institutions and must be made an essential requirement of all teachers of chemistry.

(2) Curriculums of chemistry must be rewritten or modified to include specific references to those elements of the historical background, the biographical and research narratives which should be taught. Excerpts from original researches should be printed in the course of study which the teacher is expected to follow.

(3) Textbooks must be rewritten to include the material suggested above.

(4) Other aids for developing the historical and cultural aspects of the science should also be employed, such as science club projects, scrap books, pictures of eminent chemists, and a series of films on the history of chemistry should be made available to beginners in chemistry.

Above all, the teacher of chemistry should be so immersed in the history of chemistry, so alive to the cultural value of the science, and so alert to the many vital consequences of the impact of the advance of science upon a changing society that he will unconsciously carry over to his class the same enthusiasm for a science which has within its content and method great potential survival value for the human race. At a time like this when the scientific attitude of looking at facts squarely and honestly has been all but abandoned by a large section of the world, when lawlessness in the guise of many *isms* has trampled upon all the principles of humanitarianism, when even eminent men of science have succumbed to the childish myths and symbols of dictators, when leading men of science have been forced out of their native countries to find refuge in more mentally congenial surroundings and when school laboratories are being sucked into the whirlpool of intolerance which segregates young boys and girls because of differences of racial strains and religious beliefs, it is high time that we teachers of science rededicate ourselves to the task of instilling in our pupils the conscious habit of scientific thinking, and the spiritual qualities of the true man of research.

A SIMPLIFIED CONDUCTIVITY BRIDGE ASSEMBLY

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THE disadvantages of an induction coil for use with a bridge in measurement of electrical conductivity are well known. Aside from this and the expensive Vreeland oscillator, however, the electron-tube, oscillator offers the only source of the required high audiofrequency alternating current. The author's difficulties in assembling an oscillator of the latter type have led him to feel that a description of the successful

apparatus, in such detail that only the minimum of experience will be required in its construction, may be of service to others needing this extremely useful device.

Saylor and Debruyne[1] have described an oscillator which no doubt worked satisfactorily when storage batteries were used as a source of the 120-volt direct current required, but which gave nothing but the commutator ripple when fed by a motor generator. Jones and Josephs[2] have given very exact specifications for an oscillator and bridge requiring, however, especially wound coils and containing variability features unnecessary for any but the most exacting work. The use of only six volts on the plate of the oscillator tube in the assembly described by Nutting[3] probably accounts for the necessity of the two-stage amplifier shown. Moreover, as described, a storage battery, B batteries, and alternating current are required, thus complicating power connections and lowering portability. In view of the ready availability of modern radio parts it seemed unnecessary to use other than such standard parts, or other than alternating current as a source of power, thus bringing both portability and convenience to a maximum.

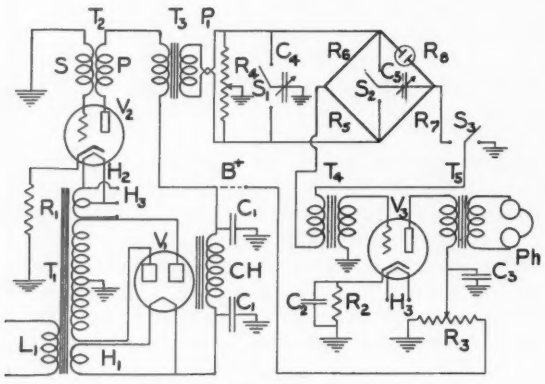

FIGURE 1

Key to Figures 1, 2, and 3.

L_1	115-v., 60-cycle power line.
T_1	Power transformer.
T_2	Audio transformer with core removed.
T_3	3/1 ratio audio transformer.
T_4	4.5/1 ratio audio transformer.
T_5	1/1 ratio, low impedance (500 ohms) coupling transformer.
V_1	'80 rectifier tube.
V_2, V_3	'56 oscillator and amplifier tubes.
H_1	5-v., 80-tube filament circuit.
H_2, H_3	2.5-v., 56-tube cathode-heater circuits.
C_1	8-MFD., 450-v. condensers.
C_2	4-MFD., 200-v. condensers.
C_3	4-MFD., 450-v. condensers.
C_4, C_5	150-$\mu\mu$f. variable condensers.
CH	8-henry choke.
R_1	2200-ohm, 1-watt resistor.
R_2	2000-ohm 1-watt resistor.
R_3	6000-ohm 25-watt resistor.
R_4	2000-ohm potentiometer.
R_5, R_6	General Radio type 500 resistors.
S_1, S_2, S_3	Single-pole, double-throw, radio-type switches.
P_1*	Connections between oscillator and bridge.
P_2	Chassis grounding connection.
P_3	Connection to resistance box R_7.
P_4	Connection to conductance cell, R_8.
Ph	Telephone connection (cord-tip jacks).

* Erroneously labeled P_1 in right-hand margin of Figure 3.

The described oscillator, bridge, and amplifier can be constructed from standard parts, available in the laboratory, or procurable from almost any radio repair shop. It is believed that with the description given it can be assembled by any chemistry teacher who can use simple tools and a soldering iron. It consists of two units, one of which contains the oscillator and its power supply or pack; the other contains the bridge, a second power pack, and the amplifier. The design is a variation of that furnished by Mr. Robert Bowyer of Yankton, which service is hereby gratefully acknowledged. Other features are taken from the articles mentioned above. The wiring diagram is given in Figure 1, and views from above and below of the finished units in Figures 2 and 3.

THE OSCILLATOR

The power pack consists of T_1, V_1, CH, the two condensers C_1, and the cord and plug connected at L_1. V_2, T_2, and T_3 constitute the oscillator proper. It was built on a $7'' \times 10''$ galvanized sheetiron chassis constructed by a local tinner, the necessary openings being cut with drill, cold chisel, and file. All grounded connections are soldered directly to this, using care to so connect only the proper leads of the electrolytic condensers. The audio transformers used had been around the laboratory a number of years, but modern types would no doubt do as well or better. The amount of inductance in the transformers T_2 and T_3 determines the tone frequency. With the two audio transformers in their original form the frequency was about ten cycles per second, increasing with a siren-like rise as the filaments cooled after the power was disconnected. This necessitated the removal of the iron core in the regenerative coupling transformer T_2, and the substitution of a wooden frame as support for the coils. The frequency is now close to 1000 cycles and the output sufficiently strong for use in elementary work in quiet locations without an amplifier. Slight variations in frequency can be obtained by variation of R_1 by connecting standard values in series or parallel, or, if the frequency should prove too high, by introduction of a condenser in parallel with the grid coil, S, of T_2. In the transformers T_3 and T_4 the left-hand coil as drawn in Figure 1 is the primary.

THE BRIDGE

The bridge circuit consists of R_5, R_6, R_7, R_8, and the balancing condenser C_5, which can be thrown across either R_7 or R_8 by means of S_2. This is the same as that used by Jones and Josephs[2] with the omission of certain refinements not justified by the accuracy of the remainder of the apparatus. S_1, S_3, R_4, and C_4 constitute

[1] SAYLOR AND DEBRUYNE, J. CHEM. EDUC., 10, 703 (1933).
[2] JONES AND JOSEPHS, *J. Am. Chem. Soc.*, 50, 1049 (1928).
[3] NUTTING, J. CHEM. EDUC., 12, 286 (1935).

the Wagner ground as described by them, and used in conjunction with the bridge proper. This is operated as follows: (*a*) S_3 is so thrown as to connect the bridge with the amplifier transformer T_4, and an approximate adjustment of the bridge is made with R_7 and C_5; (*b*) S_3 is reversed to ground the amplifier, and R_4, S_1, and C_4 are adjusted to give a minimum of sound in the telephones; (*c*) the bridge is reconnected to the amplifier with S_3 and the final adjustment of the bridge is made with R_7 and C_5. Contrary to the experience of Jones

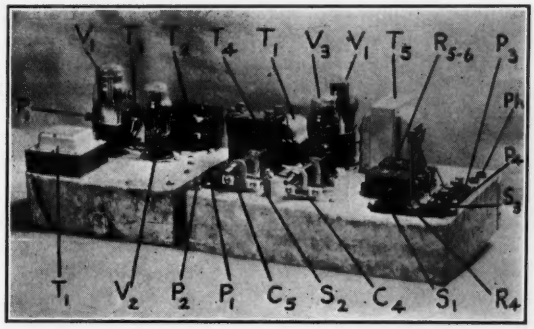

FIGURE 2

and Josephs it was found that R_4, and not C_4, made the most difference in the final adjustment. This was quite possibly due to the inherent capacity of the separate plug-type resistance box used for R_7. Care is necessary that the cases of these pieces of apparatus are insulated from the chassis—paraffined paper suffices—except where a ground connection is definitely desired. The chassis itself is grounded to a water pipe through the binding post P_2.* Two 1000-ohm coils used for the ratio coils R_5 and R_6 suffice for all ordinary class use. Availability of 10,000-, 100-, and 10-ohm coils makes possible other ratios if needed. Less expensive non-inductive resistors could no doubt be used after determining their ratio by means of a resistance box substituted for R_8. The connection between the oscillator and the bridge at P_1 was made with a fifteen-foot length of lamp cord, and the oscillator was placed on the opposite side of the laboratory to avoid stray couplings between the oscillator and amplifier coils.

THE AMPLIFIER

This includes V_3, with R_2 and C_2, T_4, and T_5 with C_3 and R_3, built on an 8″ × 12″ chassis. Because of the separation just mentioned a second complete power pack was included in the amplifier unit. To save drawing space this is not shown in Figure 1, especially since for elementary work this separation is unnecessary and the three may be combined into one unit. In this case the high potential for the 56-tube plate circuit is connected as shown by the dotted lines at B^+, and the filament is connected between the two points marked H_3, since the power transformer T_1 has ample capacity for the three tubes. For the separate units they are connected to corresponding points on the extra power pack. All such duplicated parts are marked in Figures 2 and 3. The values shown for the choke and the filter

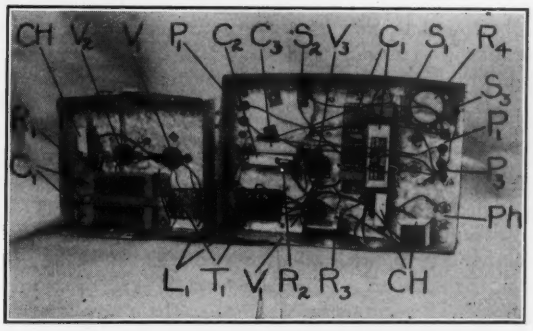

FIGURE 3

condensers were found, in the amplifier unit, to be insufficient to filter out the 60-cycle hum, and an additional choke and condenser were added, so for this or the combined units values about double those shown are recommended. Some hum is still audible but is not troublesome. The parts of the amplifier were arranged on the chassis with the possibility in mind of an additional stage of amplification if found necessary and only later were the parts of the bridge placed thereon. Consequently, the arrangement is somewhat reversed for the best connections to the bridge. The Bakelite plates for mounting the binding posts, and so forth, were taken from the cases of old radio frequency transformers.

The apparatus as built has proved capable of detecting differences in resistance of one-tenth per cent. for cells having resistances from 50 to 50,000 ohms. Its total cost, exclusive of the three transformers T_2, T_3, and T_4, was less than fifteen dollars.

* Erroneously labeled P_1 in right-hand margin of Figure 3.

FALL MEETING, DIVISION OF CHEMICAL EDUCATION

At the Milwaukee meeting of the Division of Chemical Education of the American Chemical Society, September 5th to 8th, there will be three special features: a symposium on "The Place of Science in General Education"; a round-table discussion of the subject, "What the Division Can Do to Promote the Teaching of High-school Chemistry"; and a Students' Breakfast. The latter will be an occasion at which students of chemistry from whatever school or institution, high-school, college, or university, can meet each other and some of the older well-known figures in the chemical profession. All students who intend to be present at the meeting please take notice.

A CONSIDERATION *of the* HOW *in the* TEACHING *of* ORGANIC CHEMISTRY*

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THE fervor for development during the past quarter of a century has manifested itself even in our educational institutions. The technic of teaching has undergone some noticeable changes. Some of the most marked of these advancements are to be found in the field of primary education. As a specific illustration, brief consideration will be given to improvements in the methods of teaching reading.

In this particular branch of education there are three distinct stages of development, which, in the opinion of the writer, are observable. There is, first of all, the period in which the "ABC-method" predominated. It is characterized by the emphasis which was placed upon individual symbols. The mastery of twenty-six isolated letters, with all their various sounds, was the basic requirement. This mastery, it was contended, enabled the beginner to advance to the study of words and with a fair command of words he could hope to frame sentences. The basic concept of this method is illustrated by the following example:

h t e b c r a w n o t i h h c m e t s i y r d f o e l s o a f m o
c u o p n s d e h c h t m s i r e g t y r a o n i c

In this illustration the individual letters, which convey little or no meaning, make their impression upon the eye. Fifty-nine separate impressions must be segregated and grouped into words, and then arranged into a sentence before one acquires a significant impression. This process of advancing from the specific to the general tends to stress the inductive method.

In the next stage of development in the teaching of reading, the emphasis was placed upon individual words. Scores of words, with their individual meanings, were crowded into the mind of the beginner. It was argued that words, and not letters, were the essentials for adequate expression. With a large vocabulary at one's command, it was contended that the formulation of sentences would be comparatively easy. The basic concept of this method may be clarified by the following revision of the first example:

carbon the of chemistry with deals of compounds organic the chemistry.

The fifty-nine characters of the previous example have taken the form of eleven familiar words. One's attention is no longer focused on individual letters, but upon groups of letters or words that transmit broader concepts to the mind.

In the latest development along this line, primary emphasis is placed upon the sentence. It is recognized, at last, that the sentence is the avenue of expression. The beginner is taught, therefore, to concentrate on sentences. Since words are the building blocks of the sentence, their meaning and use are acquired incidentally from correctly constructed sentences. Consideration is then given to the individual letters as the building blocks of words. The basic concept of this method is illustrated by the following revision of the previous examples:

Organic chemistry deals with the chemistry of the compounds of carbon.

The beneficial effect of this development in the teaching of reading is questioned, no doubt, by many. Only time can render the final verdict. The indications are, however, that an advance has been made in the right direction. If this be true, then consideration might be given to the application of these basic concepts to the teaching of other *beginning* subjects. Should one use the "ABC-method," should he emphasize specific cases, or should he place stress upon general concepts?

In the teaching of *beginning* organic chemistry, these three methods of approach may have their counterpart. If the chemical properties of the *alcohols* be selected as a specific example, the "ABC-method" of presentation might be represented about as follows:

ETHYL ALCOHOL REACTS WITH:

(1) *Metallic sodium to give sodium ethoxide and hydrogen,*
$2CH_3{\cdot}CH_2{\cdot}OH + 2Na \longrightarrow 2CH_3{\cdot}CH_2{\cdot}O{\cdot}Na$ (sodium ethoxide) + H_2:

(2) *Hydrochloric acid, in the presence of a dehydrating agent, to give ethyl chloride and water,*
$CH_3{\cdot}CH_2{\cdot}OH + HCl/H_2SO_4 \longrightarrow CH_3{\cdot}CH_2{\cdot}Cl$ (ethyl chloride) + $H_2SO_4{\cdot}H_2O$:

(3) *Acetyl chloride to give ethyl acetate and hydrochloric acid,*
$CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CO{\cdot}Cl \longrightarrow CH_3{\cdot}CO{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl acetate) + HCl:

(4) *Chromic acid to give acetaldehyde, sodium hydrogen sulfate, chromic sulfate, and water,*
$3CH_3{\cdot}CH_2{\cdot}OH + Na_2Cr_2O_7 + 5H_2SO_4 \longrightarrow 3CH_3{\cdot}CHO + 2NaHSO_4 + Cr_2(SO_4)_3 + 7H_2O$:

(5) *Acetic anhydride to give ethyl acetate and acetic acid,*
$CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CO{\cdot}O{\cdot}OC{\cdot}CH_3 \longrightarrow CH_3{\cdot}CO{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl acetate) + $CH_3{\cdot}CO{\cdot}OH$:

(6) *Sulfuric acid to give ethyl hydrogen sulfate and water,*
$CH_3{\cdot}CH_2{\cdot}OH + 2HO{\cdot}SO_2{\cdot}OH \longrightarrow CH_3{\cdot}CH_2{\cdot}O{\cdot}SO_2{\cdot}OH$ (ethyl hydrogen sulfate) + $H_2SO_4{\cdot}H_2O$:

* Presented before the Division of Chemical Education at the ninetieth meeting of the A. C. S., Kansas City, Missouri, April, 1936.

(7) *Ethyl hydrogen sulfate to yield ethyl ether and regenerate sulfuric acid,*
$CH_3{\cdot}CH_2{\cdot}OH + HO{\cdot}SO_2{\cdot}O{\cdot}CH_2{\cdot}CH_3$, heat $\longrightarrow CH_3{\cdot}CH_2{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl ether) $+ H_2SO_4$:

(8) *Acetic acid, in the presence of hydrogen ion and a dehydrating agent, to give ethyl acetate and water,*
$CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CO{\cdot}OH/H_2SO_4 \longrightarrow CH_3{\cdot}CO{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl acetate) $+ H_2SO_4{\cdot}H_2O$:

(9) *Phosphorus pentachloride to give ethyl chloride, phosphorus oxychloride, and hydrogen chloride,*
$CH_3{\cdot}CH_2{\cdot}OH + PCl_5 \longrightarrow CH_3{\cdot}CH_2{\cdot}Cl$ (ethyl chloride) $+ POCl_3 + HCl$:

(10) *Grignard reagent to give ethoxy magnesium halide and a hydrocarbon,*
$CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}Mg{\cdot}I \longrightarrow CH_3{\cdot}CH_2{\cdot}O{\cdot}Mg{\cdot}I$ (ethoxy magnesium iodide) $+ CH_4$:

(11) *Hydrogen bromide to give ethyl bromide and water,*
$CH_3{\cdot}CH_2{\cdot}OH + HBr$, dry $\longrightarrow CH_3{\cdot}CH_2{\cdot}Br$ (ethyl bromide) $+ H_2O$:

(12) *Phosphorus trichloride to give ethyl chloride and phosphorous acid,*
$3CH_3{\cdot}CH_2{\cdot}OH + PCl_3 \longrightarrow 3CH_3{\cdot}CH_2{\cdot}Cl$ (ethyl chloride) $+ H_3PO_3$:

(13) *Sulfuric acid at 170° C. to give ethylene and water,*
$CH_3{\cdot}CH_2{\cdot}OH + HO{\cdot}SO_2{\cdot}OH \longrightarrow CH_3{\cdot}CH_2{\cdot}O{\cdot}SO_2{\cdot}OH$ (ethyl hydrogen sulfate) $+ H_2O$, then $CH_3{\cdot}CH_2{\cdot}O{\cdot}SO_2{\cdot}OH$, heat to 170°C. $\longrightarrow H_2C{:}CH_2$ (ethylene) $+ H_2SO_4$:

(14) *Chromic acid, in excess, to give acetic acid, sodium hydrogen sulfate, chromic sulfate, and water,*
$3CH_3{\cdot}CH_2{\cdot}OH + 2Na_2Cr_2O_7/10H_2SO_4$, aq. $\longrightarrow 3CH_3{\cdot}CO{\cdot}OH$ (acetic acid) $+ 4NaHSO_4 + 2Cr_2(SO_4)_3 + 11H_2O$.

Each of the preceding equations makes their individual impressions on the mind of the beginner in organic chemistry, but there is almost complete lack of correlation. Each equation must be mastered as an isolated fact.

In the "word-method" of presentation, the same material might take a form somewhat as follows:

ETHYL ALCOHOL REACTS UNDER PROPER CONDITIONS:

(1) *To give alkoxides when treated with active metals,*
$2CH_3{\cdot}CH_2{\cdot}OH + 2Na \longrightarrow CH_3{\cdot}CH_2{\cdot}O{\cdot}Na$ (sodium ethoxide) $+ H_2$:

(2) *To give alkyl halides when treated with (a) dry hydrogen halides, (b) halogen acids in the presence of a dehydrating agent, (c) phosphorus pentahalides, or (d) phosphorus trihalides,*
(*a*) $CH_3{\cdot}CH_2{\cdot}OH + HBr$, dry $\longrightarrow CH_3{\cdot}CH_2{\cdot}Br$ (ethyl bromide) $+ H_2O$:
(*b*) $CH_3{\cdot}CH_2{\cdot}OH + HCl/H_2SO_4$, aq. $\longrightarrow CH_3{\cdot}CH_2{\cdot}Cl$ (ethyl chloride) $+ H_2SO_4{\cdot}H_2O$:
(*c*) $CH_3{\cdot}CH_2{\cdot}OH + PCl_5 \longrightarrow CH_3{\cdot}CH_2{\cdot}Cl$ (ethyl chloride) $+ POCl_3 + HCl$:
(*d*) $3CH_3{\cdot}CH_2{\cdot}OH + PCl_3 \longrightarrow 3CH_3{\cdot}CH_2{\cdot}Cl$ (ethyl chloride) $+ H_3PO_3$.

(3) *To give esters when treated with (a) acid halides, (b) acids in the presence of hydrogen ion and a dehydrating agent, or (c) acid anhydrides,*
(*a*) $CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CO{\cdot}Cl \longrightarrow CH_3{\cdot}CO{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl acetate) $+ HCl$:
(*b*) $CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CO{\cdot}OH/H_2SO_4 \longrightarrow CH_3{\cdot}CO{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl acetate) $+ H_2SO_4{\cdot}H_2O$:
(*c*) $CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CO{\cdot}O{\cdot}OC{\cdot}CH_3 \longrightarrow CH_3{\cdot}CO{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl acetate) $+ CH_3{\cdot}CO{\cdot}OH$.

(4) *To give (a) ethyl hydrogen sulfates when treated with sulfuric acid at room temperature, (b) ethers when treated with sulfuric acid and additional alcohol at about 140° C., or (c) olefins when treated with sulfuric acid and heated to about 170° C.,*
(*a*) $CH_3{\cdot}CH_2{\cdot}OH + 2HO{\cdot}SO_2{\cdot}OH$, cold $\longrightarrow CH_3{\cdot}CH_2{\cdot}O{\cdot}SO_2{\cdot}OH$ (ethyl hydrogen sulfate) $+ H_2SO_4{\cdot}H_2O$, then
(*b*) $CH_3{\cdot}CH_2{\cdot}OH + CH_3{\cdot}CH_2{\cdot}O{\cdot}SO_2{\cdot}OH$, 140°C. $\longrightarrow CH_3{\cdot}CH_2{\cdot}O{\cdot}CH_2{\cdot}CH_3$ (ethyl ether) $+ H_2SO_4{\cdot}H_2O$, or
(*c*) $CH_3{\cdot}CH_2{\cdot}O{\cdot}SO_2{\cdot}OH$, heat to 170°C. $\longrightarrow H_2C{:}CH_2$ (ethylene) $+ H_2SO_4$.

(5) *To give, depending on the conditions, oxidation products as (a) aldehydes, (b) acids, (c) other oxidized derivatives, or (d) cleavage when treated with appropriate oxidizing agents,*
(*a*) $3CH_3{\cdot}CH_2{\cdot}OH + Cr_2O_7^{=} + H_2O \longrightarrow 3CH_3{\cdot}CHO + 2Cr^{+++} + 8OH^-$:
(*b*) $3CH_3{\cdot}CH_2{\cdot}OH + 2Cr_2O_7^{=} + 5H_2O \longrightarrow 3CH_3{\cdot}CO{\cdot}OH + 4Cr^{+++} + 16OH^-$:
(*c*) $CH_3{\cdot}CH_2{\cdot}OH + 6HNO_3 \longrightarrow HO{\cdot}CH_2{\cdot}CO{\cdot}OH$ (glycolic acid) $+ 6NO_2 + 4H_2O$. Subsequent oxidation yields $H{\cdot}OC{\cdot}CO{\cdot}OH$ and $HO{\cdot}OC{\cdot}CO{\cdot}OH$, then
(*d*) $5HO{\cdot}OC{\cdot}CO{\cdot}OH + 2MnO_4^-$, aq. $\longrightarrow 10CO_2 + 2Mn^{++} + 2H_2O + 6OH^-$.

By this method of attack, the twelve isolated equations of the previous example have been grouped under five general headings according to the general nature of the products formed by the reaction.

A further extension of the technic of teaching beginning organic chemistry, corresponding to the "sentence method," might permit arrangement of the same material in a tabulation like the following:

THE MONOHYDROXY ALCOHOLS REACT UNDER PROPER CONDITIONS:

1. *By replacement of (a) the hydrogen atom of the hydroxyl group, or (b) the hydroxyl group, as indicated below when treated with:*

(*a*) 1. Active metals	R·O	H +		Na	alkoxides
2. Acid halides	R·O	H +	X	OC·R	esters
3. Organic acids/-(H_2SO_4, etc.)	R·O	H +	HO	OC·R	esters
4. Organic acid anhydrides	R·O	H +	R·CO·O	OC·R	esters
5. Alkyl hydrogen sulfates	R·O	H +	$HOSO_2O$	R	ethers
6. Grignard reagent, etc.	R·O	H +	R	MgX	alkoxy compounds

or more specifically, $2CH_3{\cdot}OH + 2Na \longrightarrow CH_3{\cdot}O{\cdot}Na$ (sodium methoxide) $+ H_2$.

(*b*) 1. Hydriodic acid/-(red phosphorus)	R	OH +	H	I	alkyl iodides
2. Hydrogen bromide (or HCl), dry	R	OH +	H	Br	alkyl bromides
3. Hydrochloric acid (or HBr)/H_2SO_4	R	OH +	H	Cl	alkyl chlorides
4. Sulfuric acid, room temperature	R	OH +	H	$O{\cdot}SO_2{\cdot}OH$	alkyl H-sulfates
5. Phosphorus trihalides	3R	OH +	P	Cl_3	alkyl chlorides
6. Phosphorus pentahalides	R	O	H + X	PX_3	X alkyl halides,

or to illustrate, $CH_3{\cdot}CH_2{\cdot}OH + HI/(P)$, heat $\longrightarrow CH_3{\cdot}CH_2{\cdot}I$ (ethyl iodide) $+ H_2O$.

2. *By dehydration, to give unsaturated derivatives,*
The ease of dehydration increases in the order $R{\cdot}CH_2{\cdot}OH$, $R_2CH{\cdot}OH$, $R_3C{\cdot}OH$ — $>C(H)(OH)$ + conc. H_2SO_4 or P_2O_5, etc.
As an example, $CH_3{\cdot}CH_2{\cdot}OH + P_2O_5$, heat $\longrightarrow H_2C{:}CH_2$ (ethylene) $+ 2HPO_3$.

3. *By oxidation, with appropriate reagents, as indicated below,*
(*a*) $R{\cdot}CH_2{\cdot}OH \longrightarrow$ (primary alcohol) $R{\cdot}CHO \longrightarrow$ (aldehyde) $R{\cdot}CO{\cdot}OH \longrightarrow$ (acid)
oxidized derivative $\longrightarrow$ cleavage:
(*b*) $R_2CH{\cdot}OH \longrightarrow$ (secondary alcohol) $R_2C{:}O \longrightarrow$ (ketone) oxidized derivative $\longrightarrow$ cleavage:
(*c*) $R_3C{\cdot}OH \longrightarrow$ oxidized derivative $\longrightarrow$ cleavage:
In the case of ethyl alcohol,
$CH_3{\cdot}CH_2{\cdot}OH \longrightarrow$ (ethyl alcohol) $CH_3{\cdot}CHO \longrightarrow$ (acetaldehyde) $CH_3{\cdot}CO{\cdot}OH \longrightarrow$ (acetic acid)
$HO{\cdot}CH_2{\cdot}CO{\cdot}OH \longrightarrow$ (glycolic acid) $H{\cdot}OC{\cdot}CO{\cdot}OH \longrightarrow$ (glyoxylic acid)
$HO{\cdot}OC{\cdot}CO{\cdot}OH \longrightarrow$ (oxalic acid) $CO_2 + H_2O$

In this illustration, an entire group of reactions is visualized in much the same way that the eye scans a group of words to discern the meaning of a sentence. Obviously, this method of teaching chemical reactions to beginners in organic chemistry has certain distinct advantages.

These correlations have served to indicate that organic chemistry, like reading and other subjects, may be taught in distinctly different ways, depending in each case on the viewpoint of the instructor. The individual instructor must, in the last analysis, decide for himself whether he will place primary emphasis upon (*a*) the individual compounds, (*b*) the types of compounds, or (*c*) the types of reactions involved.

A WORKING MODEL TO DEMONSTRATE THE EFFECT OF HEAT ON A CONFINED VOLUME OF GAS

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A PIECE of apparatus which illustrates the effect of heat on a confined volume of gas may be constructed with little time and effort, or may be undertaken as a semester project by a class in high-school chemistry.

The apparatus, diagrammed in Figure 1, below, is a working model illustrating the principle used in Hero's device for opening a temple door. Figure 2 is a photograph of the model constructed at the University of Illinois.

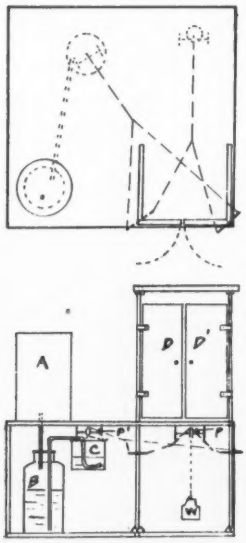

FIGURE 1

The construction is outlined briefly as follows. *A* is a fruit juice can (opened and emptied by means of a single small hole) into which a small piece of copper tubing is soldered. The other end of this copper tubing is inserted into the rubber stopper of bottle *B*, which is partially filled with water. A piece of glass tubing, extending well toward the bottom of bottle *B*, runs beneath the platform to a position immediately above beaker *C* which is supported by a cord hanging from pulley *P*. A piece of gum rubber tubing, attached to this glass tubing, extends into beaker *C*. The "doors" *D* and *D'* are mounted on two pieces of quarter-inch steel rodding, which had previously been tapered at each end. Small strips of tin, soldered to these rods at suitable positions, serve as hinges. The tapered ends of the rods are "seated" in bearings consisting of solder poured into the holes in quarter-inch brass nuts which had previously been fastened in position. Sixteenth-inch holes are drilled through the steel rods in positions which are suitable for the attachment of short pieces of iron wire. Cotton cord is attached to the ends of these wires (see Figure 1), run over pulleys, and attached to beaker *C* or counterweight *W*.

The operation consists in igniting a few strands of alcohol-soaked cord and placing them on the "altar" (top of can *A*). As the air in the can becomes heated, it expands, forcing water from *B* into *C*, overcoming the weight of counterweight *W*. As the beaker drops, the doors open. Extinguishing the flame causes a reversal of the process, and the doors return to their initial position.

The installation of a "hooded" strip of copper which is soldered to the side of the can *A* definitely increases the rate of heating the confined air. This addition to the above-described apparatus improved the operation rate. Some time is required in selecting the proper sized counterbalance. The pulleys used in the working model were obtained from an "Erector" set.

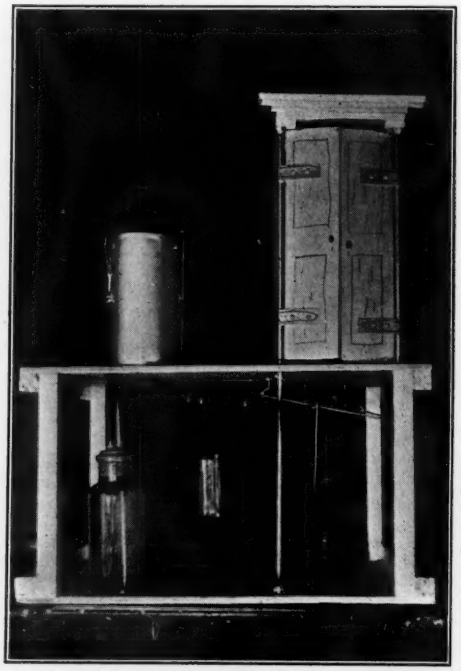

FIGURE 2

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KEEPING UP WITH CHEMISTRY

The separation of small amounts of beryllium from large amounts of aluminum light metal alloys. E. PACHE. *Chem.-Ztg.*, **61**, 880 (Nov. 6, 1937).—Dissolve 5 g. of the alloy in 100 cc. of ten per cent. sodium hydroxide, dilute with 600 cc. of hot water and boil for thirty minutes. This dissolves aluminum and zinc as aluminate and zincate and precipitates beryllium as beryllium hydroxide together with hydroxides of iron, manganese, magnesium, titanium, and chromium. Filter off the hydroxides, wash three times with cold water, remove from filter paper and dissolve in 20 cc. of dilute slightly warmed nitric acid. Add the solution to 100 cc. of freshly prepared forty per cent. sodium hydroxide (a little at a time) in a 500-cc. volumetric flask. Cool to room temperature, dilute to the mark, mix well and filter. Acidify a 300-cc. portion with nitric acid, make it ammoniacal, boil briefly, and let it settle and filter. Wash the precipitate five times with cold water, remove from filter paper and dissolve in 5 cc. of 10 normal potassium hydroxide (slightly warmed). Dilute with 500 cc. of hot water and boil forty minutes. Any turbidity formed indicates the presence of beryllium hydroxide formed by hydrolysis. Let the hydroxide settle; warm it, filter it on quantitative filter paper, wash it free from alkalies, dry it, ignite, and weigh as beryllium oxide. L. S.

The most important advances of the German chemical industry in 1937. B. WAESER. *Chem.-Ztg.*, **62**, 57–61 (Jan. 19, 1938).—A survey dealing with trade exhibitions in 1937, apparatus, synthetic and natural raw materials, aluminum and magnesium, calcium carbide, wood and cellulose, acetic acid, different organic and inorganic industrial products, medicines, water and waste water, oxygen, purification of gases, coal, petroleum, fats and oils, detergents, conservation of food, iron, and zinc. L. S.

Thallium poisoning. F. KÜNKELE. *Chem.-Ztg.*, **62**, 49–51 (Jan. 15, 1938).—The toxicity of thallium and its compounds is described as well as several fatal cases of poisoning from this source. L. S.

The preparation of acetaldehyde and acetic acid from acetylene. R. SCHARF. *Z. phys. chem. Unterricht*, **50**, 239–43 (Nov.–Dec., 1937).—Detailed laboratory procedures are given for (1) the preparation of acetaldehyde from acetylene according to the equation:

$$C_2H_2 + H_2O = CH_3CHO$$

(2) the detection of the acetaldehyde produced by means of fuchsin and sulfurous acid; (3) the formation of acetic acid by oxidation of acetaldehyde with potassium permanganate; and (4) determination of the amount of acetaldehyde formed by the formation of the oxim:

$$CH_3CHO + NH_2OH{\cdot}HCl = CH_3CH{=}NOH + H_2O + HCl$$

L. S.

A new method of preparing compounds of divalent earth metals. L. HOLLECK AND W. NODDACK. *Angew. Chem.*, **50**, 819–24 (Oct. 23, 1937).—The method is based upon the action of strontium amalgam of definite reduction potential on aqueous concentrated alkaline earth sulfate solutions whereby the trivalent earth compounds are reduced to the divalent state. The strontium sulfate formed occludes and this stabilizes a portion of the divalent alkaline earth sulfates. Such reactions were carried out on compounds of samarium, ytterbium, europium, scandium, gadolinium, cerium, praseodymium, neodymium, and mixtures of neodymium and samarium. L. S.

New analytical methods for the determination of constituents in aluminum alloys. K. STEINHÄUSER. *Angew. Chem.*, **51**, 35–8 (Jan. 15, 1938).—Methods are given in detail for the determination of iron, silicon, manganese, zinc, and magnesium in aluminum alloys. L. S.

Two new color indicators derived from beta-naphthylamine. H. EICHLER. *Chem.-Ztg.*, **61**, 796–7 (Oct. 6, 1937).—Beta-naphthylamine red is obtained by coupling one mole of beta-naphthylamine in aqueous hydrochloric acid solution with one mole of diazotized anthranilic acid and recrystallizing from ethyl or methyl alcohol. The free carboxylic acid of beta-naphthylamine red is used in alcoholic solution, is yellow in alkaline and red in acid solution. Beta-naphthylamine orange is made by coupling one mole of diazotized sulfanilic acid with one mole of beta-naphthylamine in aqueous hydrochloric acid solution and recrystallization from ethyl or methyl alcohol. Its aqueous solution is orange-red in acid and yellowish orange in alkaline solution. Both indicators give sharp color changes and can be used in place of methyl-orange and methyl-red. L. S.

Methods of analysis of commercial solvents. VII. H. H. WEBER. *Chem.-Ztg.*, **61**, 807–8 (Oct. 9, 1937).—Methods are described for differentiating carbon tetrachloride, chloroform, and methylene chloride from another and for detecting carbon tetrachloride in chloroform, methylene chloride in chloroform, and chloroform in carbon tetrachloride and in methylene chloride. L. S.

The qualitative determination of nitrates in the presence of nitrites. H. SCHNEIDER. *Angew. Chem.*, **50**, 906 (Dec. 4, 1937).—The method is based on the fact that in cold sulfuric acid solution nitrates form nitrobenzene while nitrites do not do so. Upon the addition of benzene in the presence of acids nitrites turn the solution orange, while nitrates and bromides cause only a faint light coloration of the acid. Procedure: A sample of the substance or its soda extract is treated in a test-tube with 1 cc. of concentrated sulfuric acid and cooled. Then 1 cc. of benzene is added, and the test-tube is shaken. A few drops of the benzene are absorbed on filter paper, and the excess benzene is allowed to evaporate. An odor of nitrobenzene indicates the presence of nitrates while an orange-brown color indicates the presence of nitrites. In contrast to nitrates, nitrites will produce much heat. Sensitivity: 1 mg. of potassium nitrate either alone or mixed with 0.1–0.2 gram of potassium nitrate gives a decided odor of nitrobenzene. Large amounts of iodides interfere with this test and must first be removed, if necessary, by means of silver or lead acetate. Bromides, chlorides, arsenic oxide, acetates and oxalates do not interfere.

Summary

			Benzene
sulfuric acid	colorless	no odor no nitrites no nitrates	odor of nitrobenzene nitrates alone
	immediate formation of orange-brown color	nitrites alone	nitrites and nitrates

Time of determination: Three minutes. L. S.

Cellulose situation dominates the rayon scene. W. C. MCINDOE. *Chem. Met. Eng.*, **45**, 12–5 (Jan., 1938).—The rayon industry has advanced steadily in spite of the year's financial, industrial, and labor turmoil. Rayon yarn production for 1937 has been estimated to be 325,000,000 lb. The industry is still

using both cotton linters and wood pulp for their source of cellulosic raw material. Southern slash pine, western hemlock, and Douglas fir have all been found suitable for rayon.

Of the three most prominent commercial processes, viscose, cuprammonium, and acetate, there is a strong and steady trend toward cellulose acetate. Some reasons for this are (1) the various end-products can be produced by a single plant; (2) cellulose acetate requires less cellulose per pound of rayon yarn; (3) cheaper acetic acid; and (4) a number of properties not possessed by the other types.

Rayon is invading new and important fields. The viscose type is found superior to cotton for tire fabrication and gives greater strength to canvas, duck, and sheeting. The cuprammonium type makes a typewriter ribbon with longer ink, life, and durability. J. W. H.

Recent developments widen industrial uses for rubber. H. L. TRUMBULL. *Chem. Met. Eng.*, **45**, 4–8 (Jan., 1938).—Despite the failures of many former endeavors synthetic rubbers are at present being fabricated on a fairly large scale. Germany is making "buna" from the polymerization of butadiene on a commercial scale. In the face of an average selling price five times that of crude rubber the du Pont company has had to enlarge its facilities for the production of neoprene, a synthetic rubber made from acetylene as a starting material. It has many properties superior to the corresponding products obtained from crude rubber.

The condensation product of ethylene dichloride and sodium polysulfide is sold under the name Thiokol. It is largely sulfur—over eighty per cent. in some cases. It can be mixed with pigments, extruded, sheeted, and molded in a fashion similar to rubber goods, but varies quite considerably from rubber in many properties.

New vulcanization accelerators are replacing the older types. The aldehyde amine type such as polybutyraldehyde aniline now dominate the field.

New antiscorching agents which make rubber stand up to heat in service are now being added. Benzoic, salicylic, and phthalic acids are among the many chemicals used for this.

Di-beta-naphthyl *p*-phenylene diamine is an excellent antioxidant and a number of derivatives of diphenylamine have been found to protect rubber from flex cracking.

Rubber-lined equipment, such as rod and ball mills, last longer than unlined mills.

A number of new rubber derivatives are finding increased uses. J. W. H.

Chemical engineering trends in the soap industry. O. H. WURSTER. *Chem. Met. Eng.*, **45**, 16–9 (Jan., 1938).—Improved methods of production are reflected in practically all of the older forms of soap products. Soap powders are now made by the spray process. In the production of toilet soaps the continuous automatic movement and handling of the materials has advanced to a remarkable degree of perfection. Discoloration of the finished soap has been prevented by using equipment lined with stainless steel or nickel and by the addition of inhibitors.

Fats and oils are mixed with caustic soda and by the addition of an accelerator and the heat of the reaction almost immediate saponification results. It only takes two hours to go from the raw materials to finished soap. The use of hydrogenated oils has become more general.

The development of the continuous distillation of fatty acids has brought to the soap maker fatty acids of greatly improved quality in respect to color and odor at lower cost. The refining of crude glycerine for the production of chemically pure and dynamite grades is also carried out in continuous distilling equipment.

The sulfated fatty alcohols marketed under various trade names have found extensive use for some purposes. One of their outstanding properties is that of lathering freely in hard water without forming a precipitate.

The addition of sodium hexametaphosphate to soap to prevent precipitation in hard water has made the use of soap for these conditions feasible. J. W. H.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES; TABULATIONS OF SCIENTIFIC DATA

The meaning and problems of chemistry. E. PIETSCH. *Angew. Chem.*, **50**, 934–48 (Dec. 18, 1937).—A survey. L. S.

The chemistry of germanium. E. EINECKE. *Chem.-Ztg.*, **61**, 989–91 (Dec. 18, 1937); 1011–4 (Dec. 29, 1937).—A review of the history, geochemistry, manufacture, metallic properties, alloys and compounds (oxides, germanates, peroxy acids, sulfides and sulfo salts, halides, halogen germanium acids, oxyhalogenides, nitrogen compounds, hydrides, organic germanium compounds, complex salts), analytical properties, pharmacological properties, germanium in the periodic tables. Numerous references. L. S.

The chemical technological advances of the last few years in the manufacture of glass. R. SCHMIDT. *Chem.-Ztg.*, **62**, 37–41 (Jan. 12, 1938).—A survey. L. S.

Co-enzymes. H. VON EULER. *Angew. Chem.*, **50**, 831–6 (Oct. 30, 1937).—A review of thirty-four literature references. L. S.

The latest extension of our knowledge of the sulfuric acid contact process. C. KRÖGER. *Chem.-Ztg.*, **61**, 853–6 (Oct. 30, 1937); 888–90 (Nov. 10, 1937).—A discussion of sixty-one recent articles. L. S.

The role of free radicals in gas reactions. H. SACHSSE. *Angew. Chem.*, **50**, 847–54 (Nov. 6, 1937).—A review. L. S.

Fifty years of the chemistry of fluorine. In memory of its isolation by Henri Moissan. E. EINECKE. *Angew. Chem.*, **50**, 859–85 (Nov. 13, 1937).—A survey covering the history, occurrence, preparation, physical properties, chemical properties, compounds, analytical properties, characteristics of fluorine chemistry, and literature. One hundred fifty-five references. L. S.

New phosphates. G. HEDRICH. *Chem.-Ztg.*, **61**, 793–5 (Oct. 6, 1937).—A review of the manufacture and uses of new metaphosphates, polyphosphates, and thiophates. Thirty-seven references. L. S.

The mineral oil industry in 1936. R. KISSLING. *Chem.-Ztg.*, **61**, 796–7 (Oct. 6, 1937).—A survey of the processing, uses, and examination of mineral oils. Fifty-eight references. L. S.

Vitamins and related compounds. J. WEBER. *Chem.-Ztg.*, **61**, 808–9 (Oct. 9, 1937).—A brief survey. L. S.

HISTORICAL AND BIOGRAPHICAL

Eightieth birthday of Professor Max Planck. ANON. *Nature*, **141**, 720 (Apr. 23, 1938).—On April 23 Max Planck, emeritus professor of theoretical physics at the University of Berlin, celebrated his eightieth birthday, and on the preceding evening the German Physical Society gave a banquet in his honor. Professor Planck "applied both the descriptive and the statistical methods of thermodynamics to radiation, and was successful in finding a formula for the spectral energy distribution of black-body radiation which fitted the measurements and which could be deduced on the assumption that radiation is transferred from matter in quanta of energy proportional to the frequency ν. Successive editions of Planck's book 'Wärmestrahlung' show the development and variation of the original theory, of which the underlying physical idea remained for many years a mystery to physicists, although Planck's constant h was found to enter into various relations between radiation and matter, for example, in the photo-effect. It was not until Bohr explained the laws of spectral emission of atoms by a two-fold application of Planck's constant that this latter was recognized as fundamental for all kinds of atomic action. . . When Einstein's principle of relativity showed the way out of the axiomatic and other difficulties of electrodynamics, it was Planck who took up the idea and carried it through for mechanics and thermodynamics." Although Professor Planck has received many honors, including

the Nobel Prize and the Copley Medal, they have not spoiled "his simple and unpretentious ways." M. E. W.

Dominion tributes to Lord Rutherford. ANON. *Nature*, **141**, 841–2 (May 7, 1938).—Professor T. H. Laby of the University of Melbourne has published an article on the late Lord Rutherford in the January issue of the *Australian National Review*. Dr. C. M. Focken of the University of Otago, New Zealand, has also given an account of his life and work (London, Whitcombe and Tombs, Ltd.), and Dr. E. Marsden, director of the New Zealand Department of Scientific and Industrial Research, has told of Rutherford's youth in *New Zealand Railways Magazine* for January and February, 1938. When Geiger and Marsden were working under Rutherford at Manchester, they observed "that some of the particles incident on a sheet of matter have their direction changed to such an extent that they emerge again on the side of incidence," and Rutherford set out "on his successful voyage to the nucleus." Professor A. Norman Shaw of McGill University has pointed out that "physics acquired a new status in Canada dating from that period when Rutherford 'set the St. Lawrence on fire' at the beginning of the century." Dr. R. M. Laing has contributed a brief article on Rutherford to the New Zealand fortnightly *Tomorrow* for November 10, 1937. The *Nelsonian*, the magazine of Rutherford's school, Nelson College, has an illustrated article. Dr. C. M. Focken is preparing a complete bibliography of Lord Rutherford's publications for the *Transactions of the Royal Society of New Zealand*.

M. E. W.

THE PHILOSOPHY OF EDUCATION

Tendencies disclosed by curriculum investigations in higher education and their implications for science teaching in elementary and high schools. A. W. HURD. *Science Educ.*, **21**, 147–53 (Oct., 1937).—Based on an analysis of five hundred reported curriculum investigations in higher education, the author gives the following findings: (1) need for a broad general education for all students before specialization begins; (2) new additions to the curriculum made imperative by changing life and changing knowledge; (3) curricula in higher education must be determined fundamentally by their purposes, objectives, and functions; (4) emphasis upon individual development—growth of personality—as a controlling objective of all school planning; and (5) necessity of correlation between theory and practice.

C. M. P.

GENERAL

An ethical declaration for the times. L. L. WHYTE. *Nature*, **141**, 827 (May 7, 1938).—Since "the conception of the objective truth which is the basis of science . . . is being steadily undermined" and since "science is today the only non-partisan and universal authority," this ethical declaration might well be accepted and promulgated by cultural, educational, and technical institutions throughout the world. It closes with the words: "I pledge myself to use every opportunity for action to uphold the great tradition of civilization, to protect all those who may suffer for its sake, and to pass it on to the coming generation. I recognize no loyalty greater than that to the task of preserving truth, toleration, and justice in the coming world order." It is copyright-free and may be obtained at cost from *For Intellectual Liberty*, 23 Haymarket, London, S.W. 1. M. E. W.

Genesis of the engineer's outlook. G. E. DOAN. *J. Higher Educ.*, **9**, 29–31 (Jan., 1938).—A young man in a strange city soon gives his entire life to his job. His interests, already narrowed by specialization at college or university, are now further restricted by the lack of a balanced environment such as family life provides, or the rich companionships of his college days. Is it any wonder that he can talk nothing but business after he is married? Is it surprising that he does not take an intelligent interest in his family's concerns or in community or national affairs?

When he has made a success in his professional career, when the push and hurry have led him finally into a position of some freedom from petty details and small jobs, when he pauses in his progress to contemplate what he has built and to ask speculatively, "What does it all mean?" what is his conclusion? Simply this: He is glad he has been able to provide well for his family and proud to live with some evidence of success. The men at the head of his company are men of power and position. He rejoices in his association with them. He sees things at the plant being done better and cheaper and perhaps on a larger scale than when he came. He concludes that after all, this is all there is to life.

Gradually, he has groped his way toward a solution of life's larger problems. His solutions of the larger social problems of life are his own, worked out after talking things over with his colleagues at the plant and reading the newspaper. Often he is proud of this independence of thought. His solutions are not made in the broad and mellow light of the understanding of man's problems that has come shining down to us through the ages from statesmen and philosophers. The engineer's education today provides no such cultural foundation. The high schools should, but they do not. His solutions are not made even in the light of a knowledge of present-day social diagnosis, for the average professional man is sure he cannot afford the time to read these things.

What can be done about it? Why not let it alone, let the graduate continue to find life unimportant except for his own occupation. Why try to awaken him? Is is not enough for a university to teach him how to make a material success of life? Is there anything more in life than that? A. T. B.

Preventive technology for industry. G. J. ESSELEN. Reprinted from *Industry*.—Preventive technology, like preventive medicine, is far more effective, if applied in time of prosperity before business suffers, than a curative technic employed after the emergency, or when the auctioneer enters in. In a most amazing way industrial plans today are being upset by the discoveries of research making it advisable that the successful executive seek the advice of specialists not only on matters of law and finance but the aspects of his business. The findings of scientists are seldom in a form for direct application to industrial problems and the manufacturer; therefore, he must employ an interpreter or set up a research organization of some kind. Just as finances must be audited, so it is equally essential that technological audits be made. New needs created by industry, new names and new products created by science to replace old materials, are making it necessary for even the small companies to utilize consulting services. Often it is possible to cure industrial ills and prevent serious financial consequences by employing well-equipped consultants for periodic or continuous counsel without appropriating to the purpose the large sums of money required to maintain a research organization. G. O.

Starting research for profit. G. J. ESSELEN. Reprinted from *Industry*.—When a man plans to enter a new field of business, he reduces the risk of failure by seeking the guidance of experience. Yet this simple safety measure is often overlooked in relation to chemical research as applied to industrial problems. Research requires that the work be planned and carried on under the direction of proved experience, as a consulting research organization, familiar with the direction of research projects. A manufacturer sometimes seeks to minimize his expenses by setting up a laboratory of some sort with a young man "to grow up to his job." It is usually wiser to take advantage of the young man's enthusiasm by giving him the guidance of a consulting organization. The employer is still in complete control, but such outside counseling increases his effectiveness and eliminates any unnecessary investment in expensive equipment. Its important advantage is that it provides experienced direction at the outset, eliminating technical troubles that are bound to come when business takes a gamble on "growing up with the job."

G. O.

RECENT BOOKS

THE PHYSICS AND CHEMISTRY OF SURFACES. *N. K. Adam*, Sc.D., F.R.S., Professor of Chemistry at University College, Southampton, England. Clarendon Press, Oxford, 1938. Second edition. 396 pp. 62 figs. $7.50.

Professor N. K. Adam is well known for his important contributions to the detailed picture of surface films sketched so brilliantly in outline by Langmuir twenty years ago. The rapid growth which this subject has enjoyed within this period is responsible for this second edition of a book originally published in 1930. The first edition has been a constant source of reference to the reviewer in the eight years that have elapsed, and the new volume embodying all the recent data will be increasingly valuable. There is an increase of nearly one hundred pages and a much larger increase in material by use of a smaller type which is still very legible and attractive.

The new volume presents capillarity in the first sixteen pages and then devotes nearly one hundred pages to surface films of insoluble substances. The application of film technic to the problems of structure in the sterols, chlorophyll, synthetic polymers, and proteins are welcome additions in the second edition. Chapter III deals with the surface characteristics of solutions and deals, therefore, with adsorption at such surfaces. Chapters IV and IX deal with surface tension, its measurement, and the data available from such studies. Chapters V and VII deal with the general properties of solid surfaces and the particular conditions of heterogeneity of such surfaces which affect the adsorption and reaction or catalytic characteristics of solid surfaces. The reviewer welcomes a judicial and dispassionate review of various alternative points of view in this particular field. The conditions for and mechanism of spreading on surfaces is reviewed in Chapter VI and this leads to a discussion of lubrication including a summary of Hardy's views. Chapter VIII deals with the electrical phenomena at interfaces with discussion of boundary potentials, double layers, thermionic work functions, electrode potentials, overvoltage, and electrokinetic phenomena. The material is lucidly presented at all times, with a minimum of mathematics and a maximum of verbal interpretation, is easy to read, and should be welcome not only to the specialist but to the general reader interested in chemical education, who can thereby bring himself abreast of a development which has been responsible for extraordinary advances in our knowledge of molecular structure. Two-dimensional films, perhaps even more than X-ray and electron diffraction patterns, are a powerful tool of research in organic chemical structures of great complexity where the assistance of the physical chemist, if not indispensable, is at least a great asset.

HUGH S. TAYLOR

PRINCETON UNIVERSITY
PRINCETON, NEW JERSEY

QUALITATIVE CHEMICAL ANALYSIS. *Louis J. Curtman*, Professor of Chemistry, The College of the City of New York. The Macmillan Company, New York City, 1938. Revised edition. xii + 514 pp. $3.75.

This widely used text has been very thoroughly revised to conform with present-day views as to the nature of aqueous solutions. Moreover, the ideas set forth in Part I, Theory, pages 5–120, are consistently used throughout the book.

The theoretical treatment begins with a brief statement of those essentials of atomic structure which are indispensable to understanding the nature of valence. Coördination is then discussed and dative covalence properly emphasized. This order of treatment naturally and logically brings the student to the correct view that the chemistry of aqueous solutions is, to a very large degree, the chemistry of complex ions. The Brønsted theory of acids and bases is stated and used throughout the book. The Debye-Hückel theories and the concept of ionic activities are briefly but clearly outlined. The exposition of the ideas requisite to proper understanding of the methods of analysis seems to this reviewer admirable for selection of topics, order of treatment, terseness, and clearness. Very rarely a statement is to be found which is not in accord with present views, such as that the nucleus of the atom consists of protons and electrons or that in alums the water molecules are regarded as doubled. The structure of nickel glyoximine, while differing from that set forth in the first edition, is not yet in accord with Pfeiffer's work which Sidgwick regards as settling the structure of the oximes.

Several improvements of analytical procedures have been introduced. Most notable of these are in the H_2S group of cations where the confusing and quite unnecessary reagent, yellow ammonium sulfide, has been discarded. The methods for detection of anions have been simplified and improved.

The last ten pages of the text are devoted to semimicro methods. There are several excellent cuts of the apparatus required and the methods employed, *e. g.*, separating the centrifugate from the precipitate and washing the latter. To the reviewer, in whose laboratory semimicro analysis has been used for several years, the directions appear much too brief to be useful to any except experienced analysts. Professor Curtman does not favor semimicro methods for beginners. Probably he would be the last to recommend his ten pages as an adequate guide.

In view of the author's separately published text for a one-semester course, the inclusion, pages 300–314, of a separate scheme for detection of a few anions is regrettable. The reviewer can testify from experience that in the first edition this was an annoying source of confusion to students.

The present revision is to be commended not alone as a reliable guide to qualitative analysis, but even more highly as an up-to-date reference book on the behavior of the common salts, acids, and bases in aqueous solution.

A. R. MIDDLETON

PURDUE UNIVERSITY
LAFAYETTE, INDIANA

A SCHEME OF INORGANIC QUALITATIVE ANALYSIS. *E. M. Stoddart*, B.Sc., Ph.D., Lecturer in Chemistry, College of Technology, Leicester, England. Chemical Publishing Co. of New York, Inc., New York City, 1937. vii + 39 pp. $1.00.

This handy little volume consists of the following sections: I. Preliminary examinations (the usual ignition, flame, and bead tests); II. Preliminary acid radical tests (based upon reactions with (1) water, (2) dilute HCl, and (3) concentrated H_2SO_4); III. Systematic acid radical tests (based upon reactions with (1) $HNO_3 + AgO_3$, (2) $HCl + BaCl_2$, $FeSO_4$, $FeCl_3$, etc.); IV. Separation of basic radicals into groups (using the usual cation group reagents); V. Identification of group precipitates (including six tables); VI. Detection of certain acidic radicals in the presence of each other; VII. Characteristic reactions of acidic radicals; VIII. Characteristic reactions of basic radicals.

The scope of the treatment is well indicated in the following excerpt from the preface. "No precise directions as to how to carry out the tests are given, as the writer expects that in most cases the book will be used by students who have, or have had, some guidance in carrying out ordinary laboratory operations from a teacher actually present in the laboratory. . . . .Inessential and confusing details are left out. Chemical equations have been deliberately omitted. It is expected that students will be able to account for reactions by referring to their own chemical knowledge."

American teachers will note with surprise the retention of many reactions and separations which have been displaced

by newer ones in this country. For example, the Br_2–KCN method is used to separate Ni^{++} and Co^{++}; $CaCl_2$ is separated from $SrCl_2$ by extraction with absolute alcohol; Na^+ is precipitated as the pyroantimonate. No mention is made of dimethylglyoxime as a reagent for Ni^{++}, nor aluminon for Al^{+++}, nor zinc uranyl acetate for Na^+. Groups III is precipitated as two major groups, using NH_4OH and $(NH_4)_2S$ as the group reagents, without any reference to the disturbing action of the divalent cations and of phosphate and oxalate.

The plan of having each student work out for himself, under the supervision of a "teacher actually present in the laboratory," the procedures of analytical chemistry will probably not appeal to many teachers. On this side of the Atlantic, classes are too large for such individual instruction, and it is necessary to make the laboratory manual carry a large part of the teaching load.

J. H. REEDY

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

THE ORIGIN OF LIFE. *A. I. Oparin*, Associate Director, Biochemical Institute, U. S. S. R. Academy of Science. Translation with annotations by *Sergius Morgulis*, Professor of Biochemistry, University of Nebraska. The Macmillan Company, New York City, 1938. viii + 270 pp. 14 × 21 cm. $2.75.

Oparin first traces the confusion of thought and reasoning concerning spontaneous generation from the time of the Ionian school (600 B.C.) and of Aristotle (350 B.C.) to the brilliant work of Pasteur (A.D. 1862). The broad interpretation of Pasteur's experiments, as expressed by Lord Kelvin (1871) rejected the possibility of autogeneration of life at any time, or anywhere, and the attitude was taken that life can never originate but must exist eternally. The lack of incompatibility in the theory of spontaneous generation, and the theory of the continuity of life is then discussed. Oparin quotes the contention of Engel and others that a consistent materialistic philosophy demands that life has neither arisen spontaneously nor has it existed eternally. He then addresses himself to the task of formulating theories of the origin of life at some distant period of the earth's existence.

Mention is made of Jean's conclusion that from the point of view of space, time, and physical conditions, life is circumscribed by its existence in an insignificantly little nook of the universe. The theory of cosmozoa, or the transfer of life through interstellar space is definitely rejected, since the time required for such transfers, together with the lethal effects of ultra-violet and cosmic rays, would result in killing all living protoplasm migrating through space.

Haechel's theory of archegony is held by Oparin to involve a fundamental error, namely, the implication that simplest organisms can actually arise all at once from inorganic matter. Haechel saw no difference between the formation of a crystal and of a living cell. Oparin also cautions against the acceptance of simple cell "models," such as Leduc's, as an approach to the solution of the problem of the origin of life.

Beginning with Chapter IV, Oparin sets himself to the task of arguing a chemical basis for the origin of the organic protoplasma constituents. That this becomes essentially an argument, rather than a clean-cut demonstration, is necessitated by the present lack of chemical or physical means to duplicate nature's syntheses. The present physical state of the stars and planets, and the syntheses of *C* and *N* compounds in them, is discussed. Thus it is concluded that *C* first appeared on the cooling earth mass as hydrocarbons derived from primordial carbides, *N* as ammonia; both thus being in the reduced state. Primary carbohydrates and proteins may have been formed "in any part of the primitive ocean and in every water reservoir, pool, or drying up basin . . . in these primitive waters materials were created out of which living organisms were to be built up subsequently" (page 127). The simple and somewhat naïve approach to this assumption finds its origins in the statement that "the chemist succeeded in synthesizing *in vitro*, in his flasks and test-tubes under artificial conditions, practically all the known organic substances, and, therefore, no one is any longer justified in questioning the possibility of a primary origin of these substances" (page 62). This might be regarded as the expression of a wish, or of a prospect for later accomplishment, but could be challenged as an actual achievement of the present. Thus the author concedes "we still lack a definite conception of the structure of the protein molecule."

In his discussion of the origin of primary colloidal systems, Oparin is on safer ground, since the very materials which he employs in his discussion are colloidal and hence possess the properties characteristic of that physical state. Likewise, his treatment of the subject of enzymes, particularly as they are involved in energy transfers, is clever and rather convincing. If proteins can result from a sequence of chance reactions, why not enzymes as well? Evolving a living cell from these materials is not so simple, however, and even the structure of the primary cell is not apparent. It is significant that Oparin chooses an anaërobic metabolism as the primitive one, with inorganic sources of energy as most probable.

In the summarizing chapter, the author virtually acknowledges the hopelessness of a demonstration of the evolutionary progression in the natural synthesis of living protoplasm. He assembles facts for a neat hypothesis, albeit replete with wide gaps. The sequence employed is coherent enough to be plausible as far as it goes, and at any rate it serves to stimulate serious thought along these lines.

Dr. Morgulis' contributions as translator must have been a substantial one, and the Russian text is transferred to us in very readable English.

C. H. BAILEY

UNIVERSITY FARMS
UNIVERSITY OF MINNESOTA
ST. PAUL, MINNESOTA

CATALYSIS FROM THE STANDPOINT OF CHEMICAL KINETICS. *Georg-Maria Schwab*, Professor-Extraordinary of Chemistry at the University of Munich. Translated from the first German edition by *Hugh S. Taylor*, Princeton University, and *R. Spencer*, Leeds University. D. Van Nostrand Company, Inc., New York City, 1937. 15 × 23 cm. $4.25.

The German edition of this book appeared in 1931. The appearance of the English translation has been delayed, as explained by the translators, by unfavorable economic conditions. Although the German edition has been well received the appearance of the translation of this edition after the lapse of so many years would not create much interest, as the field dealt with has so many important applications in so many fields that progress in the meanwhile would require a new edition to bring it up-to-date.

This book, however, is much more than a mere translation as the author and the translators have coöperated in bringing the translation up to date by copious additions from the recent literature. The added references are noted by letter subscripts. Much more is accomplished in this translation than mere citations from recent literature. The translation contains, in fact, more than one hundred additional pages than the German edition. Its three hundred fifty pages are almost equally divided between homogeneous catalysis and heterogeneous catalysis.

It is remarkable how thoroughly the field has been covered and for this reason treatment in any great detail is impossible.

To the reviewer the most important feature of the translation are the copious references to the literature which in great measure overcome the lack of detail in the text.

The subject of catalysis has not yet reached a stage of development where it can be taught explicitly. No theory of heterogeneous catalysis does more than correlate a certain number of experimental facts and sooner or later fails to account for others. The mechanism of heterogeneous catalysis has not been explained in spite of the valiant efforts of the author and translators. This leaves one with some choice as to the mechanism of catalysis and requires an implicit method of instruction, and

here the importance of the numerous references to the literature is especially valuable.

The translation should be in the hands of everyone interested in the subject of catalysis, as in the judgment of this reviewer it is the most helpful book available on this subject.

J. C. W. FRAZER

THE JOHNS HOPKINS UNIVERSITY
BALTIMORE, MARYLAND

SOILLESS GROWTH OF PLANTS. *Carleton Ellis* and *Miller W. Swaney*. Reinhold Publishing Corporation, New York City, 1938. 14.5 × 23 cm. 155 pp. 58 figs. (including 3 color plates). $2.75.

In view of the recent growth of popular interest in "hydroponics" or aquaculture this simply written, but authoritative and informative, little volume should meet with a warm welcome. It treats not only of methods of water-culture, but also of growth in mineral aggregates and other neutral media, fed by nutrient solutions.

The first chapter is devoted to a non-technical exposition of the essentials of the chemistry of plant life. With this background even the amateur horticulturist of no technical training whatever should be able to follow intelligently the discussion that follows. Specific formulas are given, and practical mechanical accessories are described and fully illustrated. The hobbyist and amateur experimenter are wisely advised to use simple and inexpensive equipment, and to devise and construct that which best suits their own needs.

The "trace" elements (such as boron, manganese, and so forth) as well as the so-called plant hormones, are briefly discussed. The effects of light and of various gases are also outlined.

The advantages and limitations of soilless culture are fairly and conservatively stated. Several commercial developments are mentioned. The reader is warned against unscrupulous exploitation by equipment and nutrient sellers, and should have no difficulty between "gyp" and honest dealers in the light of the information which this little volume places at his disposal.

Format, illustrations, and typography are excellent. There is an index and a few blank pages for memoranda.

OTTO REINMUTH

BASIC GERMAN FOR SCIENCE STUDENTS. *M. L. Barker*, University of Edinburgh. Third edition. Chemical Publishing Co. of New York, Inc., New York City, 1937. xiii + 186 pp. 15 × 23 cm. $2.50.

According to the preface, "The present book is the outcome of the author's practical experience in teaching university students to acquire a 'reading knowledge' of German for the purposes mentioned above," *i. e.*, . . . "learn enough German to enable him (1) to give in English the gist of the German passage set in his final B.S. paper, and (2) to understand German articles in books and periodicals dealing with his special subject or research work.' "

Part I (forty-seven pages) devotes twenty-two pages to an introduction which includes all the grammar (conjugations, declensions, and so forth) in the book and all thirty-one verses of chapter one of Genesis with appropriate vocabulary. An English translation of each verse is presented beside the German text. The remaining twenty-five pages of Part I have short German passages relating to the history of civilization on the left-hand page (with vocabulary as footnotes) and an English translation on the right-hand page. The author states, "The introduction and Part I provide the student with the material necessary for acquiring a vocabulary of approximately six hundred fifty of the first thousand basic German words, *i. e.*, 'those words which are actually of most frequent occurrence in the writings of the German people.' " Part II (eighty pages) consists of German scientific passages on the left-hand side and an English translation on the right with vocabulary as footnotes. Of Part II twenty-two pages are devoted to chemistry, ten to zoölogy, eight to botany, fourteen to physics, ten to mathematics, and sixteen to medicine. One page is devoted to twenty-eight common German abbreviations, another to twenty-nine technical terms in chemistry and a third to a few very elementary ideas on inorganic chemistry nomenclature. The next twenty-nine pages are devoted to vocabulary and the final twenty-four pages to reproducing German passages set in papers for the final B.S. examinations in various fields of science. One page is given to "Practical hints on the pronunciation of German."

This book is not intended for use in class work and is not suitable for this purpose. It does fulfill the objectives stated in the preface in a very condensed but effective fashion. The scientific passage selections are well made, mostly from standard texts and of German of moderate difficulty, and the English translations follow the German text very closely but, despite this fact, are in excellent English. From the treatment of pages like those on common technical terms in chemistry and on nomenclature it is obvious that the author is not a chemist and probably not trained in the sciences. A chemist would not be content with such elementary and incomplete treatment of these topics. For the person who must acquire a reading knowledge of German by his own efforts, this book should prove very useful. It is doubtful whether the American student will get much value from the passages from B.S. examinations, as those passages commonly given in language examinations in American universities for graduate degrees are much longer and usually more difficult German.

The book is well manufactured and exceptionally free from errors, as the reviewer failed to find a single error. The space arrangement of the text is not too good, as twenty-four pages were noted that were over half blank and about an equal number had too much unused space.

ODEN E. SHEPPARD

MONTANA STATE COLLEGE
BOZEMAN, MONTANA

THE FOUNDATIONS OF NUTRITION. *Mary Swartz Rose*, Columbia University. Third edition. The Macmillan Company, New York City, 1938. xi + 625 pp. 116 figs. 14 × 21.5 cm. $3.50.

The third edition of THE FOUNDATIONS OF NUTRITION, like its predecessors, presents in an accurate and readable form the story of the development of the science of nutrition and its practical application. It should serve equally well as a guide to food selection for the intelligent layman and as a text for the college student of food and nutrition.

The new chapter on "Vitamins of Undetermined Significance in Human Nutrition" comprises a timely addition. It serves to present to the beginner and those unfamiliar with the extensive vitamin literature evidence for the multiplicity of the B complex. It presents lucidly and briefly the necessary experimental work upon which this evidence is based. There will be some difference of opinion as to the wisdom of designating riboflavin vitamin G. This objection is particularly justifiable in making an appraisal of the tables in the appendix. Few of the animal assays for the G value of foods can be said to be determinations of riboflavin only.

The summaries at the end of the chapters on the contributions to the diet made by various types of food materials is a valuable addition to the book. Such a summarization is most useful to the lay person with but a casual interest in foods and their importance in the diet. For the more careful student of nutrition there is sufficient detail in the subject matter of these chapters to afford a thorough understanding of the reasons for the variations in biological value of individual foods and different classes of foods.

This book is admirably written and will undoubtedly find favor among new readers, as well as among those familiar with the preceding editions.

E. V. MCCOLLUM

SCHOOL OF HYGIENE AND PUBLIC HEALTH
BALTIMORE, MARYLAND

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Fillox is a new laboratory paint distributed by *Scientific Glass Apparatus Company, 49 Ackerman Street, Bloomfield, New Jersey.* Fillox enamels are based on non-oxidizing, non-saponifying, urea resins that contain no nitro-cellulose or oil-soluble compounds. These enamels can be brushed or sprayed on. They dry quickly, forming a smooth, glossy finish. According to a bulletin issued by the company, a coat of Fillox, corrosive-resistant paint, will protect laboratory walls and tables from the effects of destructive fumes and chemicals.

Alcohol-Gasoline Blends

Bulletin No. 1 of the Motor Fuel Facts Series has just been published by the *Committee on Motor Fuels of the American Petroleum Institute, 50 West 50th Street, New York, New York.* This bulletin discusses the various technical characteristics of alcohol-gasoline blends. According to the Foreword, the views stated in the bulletin are "based on extensive study and research by qualified experts and present the joint conclusions of many competent minds. Data considered have been obtained by automotive engineers under carefully controlled "consumer tests" on which many extravagant technical claims for blends have been based." Copies of the bulletin may be had by writing the institute.

Ponsol

A new dyestuff color for the textile trade is announced by the *du Pont Company* in "Ponsol" Golden Orange YL Double Paste. The latest addition to the du Pont range of anthraquinone vat dyes, it yields yellowish shades of orange on cotton and rayon in all forms. It is a trace redder and duller than "Ponsol" Golden Orange G Double Paste and is in physical condition for application in all types of dyeing apparatus, being particularly recommended for pigment-pad work. The new color is resistant to light, chlorine, washing, and power laundering with chlorine and changes only slightly in tone when given the usual soaping finish.

New "Rentschlerizing" Equipment

For killing bacteria and preventing mold in many fields including the meat industry, baking industry, hospitals, public eating and drinking places, the Lamp Division of the *Westinghouse Electric and Manufacturing Company* announces a new line of equipment for use in "Rentschlerizing." Just as pasteurization is known as a means of sterilizing through the use of heat, so the Rentschler-James Process, or "Rentschlerizing" is known as a means of sterilizing through the use of selected ultra-violet radiations produced by Sterilamps. The Sterilamps are slender rod-shaped glass tubes with effective lengths of 10″, 20″, or 30″. Two types of fixtures have been specially designed for use with Sterilamps. SB-30 is suitable for walk-in refrigerators and other places where ceiling or wall mounting is desirable and is equipped with a flat Alzac-finished aluminum reflector. SC-30 is an open type fixture particularly designed for use in refrigerated display cases and shelves. Both types are complete with sockets, terminal boxes, and necessary hardware for mounting. A special power unit is used for energizing the tubes.

In appearance the Sterilamp is a slender, rod-shaped glass tube, flaring slightly at each end where the electrodes are located. It operates on the gaseous discharge principle in an atmosphere of inert gases and mercury vapor. Over eighty per cent. of the radiant energy produced by the Sterilamp is in the region of 2550 Å., which provides the most effective bactericidal energy for the power consumed.

All-Metal Weston Laboratory Thermometer

These virtually unbreakable, all-metal laboratory thermometers operate on a stable, scientific bi-metal principle of temperature indication.

The dial type scale, with legible figures and markings, makes the Weston Laboratory Thermometer easy to read. It can be read quickly while in use without removing it from the liquid or gas.

This scientific laboratory thermometer carries a guaranteed accuracy of $\frac{1}{2}$ of 1%—1°F. per 200°F. or $\frac{1}{2}$°C. per 100°C. They are individually tested for accuracy. To obtain the most accurate reading, it is only necessary to insert at least 2″ of the stem in liquids, and 4″ in gases.

The eight-inch stainless steel stem is made of an 18-8 alloy which is corrosion resistant to most acids and gases. As protection against the few corrosive acids which attack stainless steel, the thermometer may be inserted in a glass tube, sealed at the lower end. Or, on special order, these thermometers can be supplied with acid-resisting, rubber-coated stems. Such protective measures do not affect the accuracy of the temperature indications. These thermometers are unaffected by vibration or reasonable over- or under-temperatures. No capillary correction is necessary. Weston Laboratory Thermometers are available in a choice of ranges to suit various laboratory requirements. *Weston Electrical Instrument Corp., Newark, N. J.*

Yumidol

Glycerin, which is used extensively in many industries, has one serious disadvantage which limits or precludes its use for numerous purposes where otherwise it would be of considerable service. The disadvantage referred to is its hygroscopicity. In hot humid days, owing to its water-absorbing powers, glycerin increases in weight and decreases in viscosity, whereas in cold dry weather it loses its absorbed water very rapidly. Thus, materials treated with glycerin, or products containing glycerin, are apt to change their appearance, feel, weight, and even form and shape. In order to overcome this, the *Glyco Products Co., Inc., 148 Lafayette Street, New York City,* have just introduced a special grade of sorbitol known as Yumidol. This material, which is a straw-colored viscous liquid, has a higher specific gravity, viscosity, and refractive index than glycerin. It is less hygroscopic in moist air and it retains its moisture longer than glycerin does in dry air. Changes, therefore, under varying conditions of humidity are much less drastic than when glycerin is used. Yumidol is made from vegetable raw materials and contains no animal matter whatsoever. Its use is indicated in place of glycerin for purposes where animal matter is objectionable. It can also replace sugar where the latter is undesirable because of physiological or fermenting effects. Yumidol is soluble in water, alcohol, methanol, glycols, and glycerin and most water-soluble materials. It is insoluble in oils, fats, waxes, resins, and other water-insoluble materials. It is non-inflammable and non-volatile and does not produce acrolein or other acrid products even on prolonged heating. Its use is suggested as a softener, plasticizer, and flexibilizer for paper, textiles, leather, cork, wood veneers, gaskets, adhesives, printers' rollers, hectograph pads, tooth pastes, tobacco, and so forth; as a suspending agent for pigments, abrasives, polishes, water colors, water-soluble inks; as a thickener and bodying agent for lotions, pharmaceuticals, and other aqueous fluids; and as an electrical conductor for electrolytic condensers; and as a vehicle for conductive pastes.